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During the period of 1974 to 1977, the Regional Air Pollution Study (RAPS) was conducted in the St. Louis, Missouri/Illinois Metropolitan Area. In addition to EPA-funded contractor personnel, RAPS participants included scientists from numerous universities, private research organizations, and other governmental agencies. Because of the availability of extensive monitoring data, additional independent research studies were conducted in the St. Louis area during this time frame.

This report is an attempt to document nearly all the RAPS and related investigations conducted in the St. Louis Air Quality Control Region during the period of 1973 to 1978. Descriptions of locally-operated air quality and meteorological networks are also included. Such a report will serve as a summary of data available to the EPA modelers in pursuit of the RAPS objectives and will be used by RAPS researchers to locate supplementary data sources to augment their own measurements.

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DOCUMENTATION OF THE REGIONAL AIR POLLUTION STUDY (RAPS) AND RELATED INVESTIGATIONS IN THE ST. LOUIS AIR QUALITY CONTROL REGION

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FOREWORD

The Environmental Sciences Research Laboratory (ESRL) conducts an intramural and extramural research program in the physical sciences to detect, define, and quantify air pollution and its effects on urban, regional, and global atmospheres and the subsequent impact on water quality and land use. The Laboratory is responsible for planning, implementing, and managing research and development programs designed to quantitate the relationships between emissions of pollutants from all types of sources and air quality and atmospheric effects and to uncover and characterize hitherto unidentified air pollution problems. Information from ESRL programs and from the programs of other Government agencies, private industry, and the academic community are integrated by the Laboratory to develop the technical basis for air pollution control strategies for various pollutants.

The Regional Air Pollution Study (RAPS) was organized to quantify the effects of emitted air pollutants on air quality over the scale of an Air Quality Control Region. The Study, performed in the St. Louis, Missouri-Illinois metropolitan area included use of state-of-the-art measurement and monitoring procedures, development of emission inventory methodologies and data, conduct of intensive field investigations to describe atmospheric effects on pollutant dispersion and composition, and improvement and verification of air quality simulation models. These components of the RAPS, together with related investigations and measurements are described here to furnish a compendium of studies and data sources for investigators employing information from these many components.

A.P. Altshuller
Director
Environmental Sciences Research Laboratory

ABSTRACT

During the period of 1974 to 1977, the Regional Air Pollution Study (RAPS) was conducted in the St. Louis, Missouri/Illinois Metropolitan Area. In addition to EPA-funded contractor personnel, RAPS participants included scientists from numerous universities, private research organizations, and other governmental agencies. Because of the availability of extensive monitoring data, additional independent research studies were conducted in the St. Louis area during this time frame.

This report is an attempt to document nearly all the RAPS and related investigations conducted in the St. Louis Air Quality Control Region during the period of 1973 to 1978. Descriptions of locally-operated air quality and meteorological networks are also included. Such a report will serve as a summary of data available to the EPA modelers in pursuit of the RAPS objectives and will be used by RAPS researchers to locate supplementary sources of data to augment their own measurements.

Each individual component study is described in terms of funding source, period of performance, summary of effort, representative publications, contractor Principal Investigator, and EPA Project Officer of Task Coordinator. For those components which include measurements, additional descriptive categories include parameters measured, instruments/methods used, periods of data collection, calibration and quality control procedures, and location and type of data available.

This report was submitted in fulfillment of Task Order No. 122, EPA Contract No. 68-02-2093, by Rockwell International Environmental and Energy Systems Division under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period from 1973 to 1978, and work was completed as of July 1979.

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1.0 INTRODUCTION

For a number of years, scientists in the field of air pollution and urban meteorology have recognized the need for a comprehensive study of an urban area in which all the interrelated processes affecting pollutant emission, dispersion and composition, as well as the state of the atmosphere, could be investigated jointly. Additional impetus was provided for such an undertaking by the Air Quality Act of 1967 and the Clean Air Amendments of 1970. Specifically, in addition to other duties, the Congress charged the U.S. Environmental Protection Agency (EPA) with encouraging and assisting the development and operation of regional air pollution control programs.

This scientific inquisitiveness and Congressional mandate combined to produce the St. Louis Regional Air Pollution Study (RAPS), a major program of the EPA Office of Research and Development (ORD). Specific focus for the study was provided by a White House initiative in late 1971, calling for the development and validation of improved air quality simulation models upon which least-cost pollutant control strategies could be based. Hence, the three major objectives sought of the RAPS are:

1. To develop, evaluate, and validate air quality simulation models (AQSM) on a regional scale covering urban and rural stationary and mobile sources.
2. To develop, evaluate, and validate models of local-scale phenomena that complement regional scale models.
3. To create a comprehensive, accurate, and readily retrievable data base for all criteria pollutants (sulfur dioxide, particulates, carbon monoxide, nitrogen oxides, oxidants, and hydrocarbons) and selected non-criteria pollutants to use in evaluating air quality simulation models.

The verification and development of quantitative relationships between sources of pollution and ambient air quality measurements on the scale of an air quality control region will allow control techniques to become more sophisticated and selective. General control actions can be confidently tested through these relationships to develop regional strategies which provide the desired level of control for the lowest cost. The verification and development of such relationships will also allow impact on air quality to become a factor in community and industrial planning for future growth, and can be utilized to optimize the size of a monitoring network needed to define a region's air quality.

1.1 STUDY DESIGN

Thirty-three Standard Metropolitan Statistical Areas larger than 400,000 population were evaluated by the Standford Research Institute in terms of pollutant backgrounds, heterogeneous emissions, existing pollution control programs, and climatic conditions (Section 2.1). On the basis of these criteria, the St. Louis Missouri/Illinois Metropolitan Area emerged as the site of the RAPS field measurement program. With an anticipated $25 million budget, the Interdepartmental Committee on Atmospheric Science (ICAS) requested the EPA to serve as the lead agency for the RAPS over a five-year period. The first two years were devoted to planning, facility construction, and preparatory research. The major field measurement program began in mid-year of 1974 and concluded in June 1977.

The Air Monitoring Center of Rockwell International was awarded a two-year contract by the EPA in 1973 to conduct the RAPS. A follow-on contract was negotiated with Rockwell in 1975 to complete the field portion of the study. Aided by subcontractors, Rockwell, as prime contractor was charged with establishment and operation of the routine RAPS air quality and meteorological measurement networks and the data handling facility.

Additionally, the prime contractor supported the RAPS research program by specialized atomospheric sampling, sample analysis, data processing, and data analysis. These specialized functions were conducted under a mechanism whereby individual task orders were issued as the need arose. Approximately ninety task orders were completed as part of the RAPS field measurement program. Additional RAPS participants included numerous universities, private research organizations, and other governmental agencies.

RAPS is structured as an orderly progression of efforts, partially simultaneous, but mostly consecutive. The first major step, the field measurement program, has been completed. This step was responsible for providing suitable types of measurements for the model evaluation and development.

Next is data management, made necessary by the sheer volume of data routinely obtained by the field measurement program. The final step consists of model evaluation and development, for example, the testing and verification of existing systems of simulation models and the development of improved models.

These three efforts are closely related and interdependent. Assumptions concerning the sources and atmospheric processes in the various models directed, through the data management step, the collection of data; analysis of the data collected will confirm or refute these assumptions, and may, in fact, disclose unexpected relationships that change the model structure.

The general design of the RAPS field measurement program consisted of continuous measurements from a 25-station telemetering Regional Air Monitoring System (RAMS) to provide an extensive data base for model evaluation and development; an Upper Air Sounding Network (UASN) for information on meteorological structure aloft; emissions data obtained through an extensive emissions inventory effort; and expeditionary studies to describe particular atomospheric processes to be incorporated as model modules or sub-models.

RAPS data have been provided to various participants in related studies who chose the St. Louis Metropolitan Area as a base of operations. In addition, RAPS scientists have exchanged visits with Soviet scientists under an environmental protection agreement between the U.S.A. and the U.S.S.R. in which the metropolitan areas of St. Louis and Leningrad were designated as subjects for air pollution investigations. During these visits, information was exchanged, joint technical documents prepared, and proposals advanced for cooperative research efforts.

1.2 REPORT STRUCTURE

This report contains documentation on nearly all the RAPS and related investigations conducted in the St. Louis Air Quality Control Region during the approximate period of 1973-1978. Descriptions of locally-operated air quality and meteorological networks are also included.

On the one hand, this report is intended to serve as a summary of data available to the modelers in pursuit of the ultimate RAPS objective, i.e., the development, evaluation, and validation of air quality simulation models. On the other hand, researchers are encouraged to use this summary to locate supplementary sources of data to augment their own measurements obtained in the St. Louis RAPS study area.

The list of publications at the end of each section is intended to be representative, not exhaustive. Additional information on particular activities may be obtained by contacting the appropriate Principal Investigator, Task Coordinator, or Project Officer.

2.0 PROGRAM MANAGEMENT

Introduction

The initial planning document for the Regional Air Pollution Study (RAPS) was a Prospectus prepared by Stanford Research Institute (SRI) for EPA. It consisted of four volumes: Part I-Summary, Part II-Research Plan, Part III-Research Facility, and Part IV-Management Plan. Summaries of the four volumes follow.

Copies of the four volume report and additional information may be obtained by contacting:

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2.1 RAPS PROSPECTUS

Principal Investigator	Project Officer
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Funding EPA Contract No. 68-02-0207

Period of Performance August 1971 - January 1972

RAPS Prospectus, Part I - Summary

In Part I - Summary, the concept of RAPS was presented, along with an outline of the Research Plan, the Research Facility, and the Management Plan which were described in subsequent volumes.

The basic purpose of RAPS, according to the Prospectus, was to evaluate and demonstrate how well the effectiveness of air pollution control strategies on all scales appropriate to air quality within a region could be assessed and predicted. Furthermore, RAPS was to serve as the basis for developing improved control strategies that could be generally applied.

Both purposes required the development of a better understanding of the chemical, physical, and biological processes entailed in determining pollutant concentrations and air quality modification. They also required increased comprehension of certain human, social, and economic factors significant in formulating control strategies. Additionally, both purposes required the testing, verification, evaluation and improvement of mathematical simulation models that are the basic tools of scientific air quality management and a knowledge of how such models could be used most effectively.

Hence, the overall purpose of RAPS was to provide the basis necessary for the formulation of control strategies rather than to develop actual control and abatement procedures.

Also included in Part I were organizational procedures relating RAPS to other EPA activities, a summary of criteria considered in selecting St. Louis as the study site, and finally, a summarized cost analysis.

Publication

Collis, R.T.H., and D.R. Scheuch. Regional Air Pollution Study: A Prospectus, Part I-Summary. Stanford Research Institute, Menlo Park, California. EPA Contract 68-02-0207. January 1972.

RAPS Prospectus, Part II - Research Plan

Part II of the Prospectus presented the RAPS Research Plan in two phases. The first phase provided a detailed overview of the three principal components of air pollution: meteorological processes, atmospheric chemistry and transformation processes, and emission sources. The second phase defined specific research tasks to be carried out during the study.

Considerations of meteorological processes covered their general involvement and effects on relationships of their magnitudes to air pollution and the manner in which these processes are treated in several mathematical models having a relatively advanced degree of development.

Discussion of atmospheric chemistry and transformation processes covered the atmospheric pollutant cycles of the principal pollutants, including SO_x, NO_x, CO, hydrocarbons, particulate matter and photochemical oxidants. The atmospheric cycles of most of these pollutants are not well understood, and recommendations were presented for improvement in the state of knowledge of these cycles in their most critical sectors. The function of particulate material as a scavenger for many pollutants was addressed, along with the role of precipitation in removing both gaseous and particulate material from the atmosphere.

In regard to emission sources, the need for, and the procedures necessary to develop and maintain a source inventory were discussed. The inventory was divided into stationary and mobile sources and subdivided, respectively, into area and point sources, and area and line sources. A further breakdown was made into combustion and noncombustion sources. Data acquisition methods were also treated.

Also addressed in the discussion of the first phase were: companion research efforts that could be carried forward in the area of economic and social implications of air pollution and programs for its control and abatement; the concept that RAPS would include developments and advances in instrument systems, data handling and processing, model verification, and many other areas that could be profitably adapted for use in similar or quite different areas of research as well as operation; and the need for RAPS to interact with a number of other ongoing research efforts in the St. Louis area.

The second phase of the Research Plan consisted of a set of specific research tasks, along with estimates of the scheduling and personnel requirements for each task. The tasks, placed within four principal groups, were:

model verification;

atmospheric chemical and biological processes;

human, social, and economic factors; and

transfer of RAPS technology.

Publication

Collis, R.T.H., and D.R. Scheuch. Regional Air Pollution Study: A Prospectus, Part II-Research Plan. Stanford Research Institute, Menlo Park, California. EPA Contract 68-02-0207. January 1972.

RAPS Prospectus, Part III - Research Facility

Part III of the Prospectus included specifications and a detailed discussion of the permanent instrument, data handling, and processing facilities proposed in support of the Research Plan presented in Part II.

The St. Louis research facility was conceived as a system of fixed and mobile air quality and meteorological instrument stations located within a 100-km radius of the Gateway Arch. A central support facility was also detailed which included data handling and processing equipment, office and laboratory space, and repair and maintenance shops. Fixed instrument stations were to be linked by telephone circuits to the central facility to permit automated remote data recording. Mobile stations were planned to have self-contained data recording facilities.

Part III discussed in detail the criteria for selection of St. Louis as the study site; the near-surface atmospheric monitoring network; air quality sampling; the data acquisition and handling system; the mixed layer observation program (including helicopter and balloon-tracking measurements); the general climatology of St. Louis; and finally, specific land and building requirements for the central facility and instrumented station sites.

Publication

Collis, R.T.H., and D.R. Scheuch. Regional Air Pollution Study: A Prospectus, Part III-Research Facility. Stanford Research Institute, Menlo Park, California. EPA Contract 68-02-0207. January 1972.

RAPS Prospectus, Part IV - Management Plan

Part IV of the Prospectus presented findings applicable to the scheduling, management and staffing, and estimated costs of the St. Louis research facility. It also summarized the estimated costs of the Research Plan presented in Part II and the costs of the mixed layer observational program presented in Part III.

The planning factors presented were regarded as suitable for the purposes of the Prospectus and for providing a working format for additional, more detailed planning efforts.

The management and staffing requirements defined in Part IV included permanent groups located at Research Triangle Park and St. Louis having responsibilities, respectively, for overall management and coordination of the Regional Air Pollution Study, and for operation of the St. Louis research facility and field support of the research experiments.

The research facility costs for RAPS were divided into two principal categories. The first included the initial costs of the St. Louis instrument system and its associated communications network, data processing equipment, and the like. The second covered the annual operating costs of the St. Louis research facility including personnel costs of the permanent staffs located at both St. Louis and Research Triangle Park.

Publication

Collis, R.T.H., and D.H. Scheuch. Regional Air Pollution Study: A Prospectus, Part IV-Management Plan. Stanford Research Institute, Menlo Park, California. EPA Contract 68-02-0207. January 1972.

2.2 PROGRAM PLANNING

2.2.1 RAPS STUDY PLAN

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Funding Environmental Protection Agency

Period of Performance August - October 1972 (revised April 1973)

Summary

This report presented the EPA Study Plan for the initial phase of the RAPS program. Much of the report was a restatement of the preliminary plan prepared by Stanford Research Institute (SRI) presented previously (Section 2.1). However, considerable departures from the SRI study are found in the details of the planned research and field facilities.

Section One of the EPA report presented the background, purpose and objectives of RAPS, and an affirmation of the selection of St. Louis as the study site.

The Facility, presented in Section Two, included an introduction to the Regional Air Monitoring System (RAMS), siting criteria, and a proposed network. The primary purpose of RAMS was defined to be the production of a comprehensive data base relative to air quality and meteorological conditions. Facilities were also discussed for above-surface measurements and for non-routine data acquisition.

Section Three, Management and Scheduling, delineated responsibilities of the principal staffs at Research Triangle Park and St. Louis. General responsibilities of the Prime Contractor were also defined and included the design, installation, testing, operation and maintenance of the St. Louis research facility. A facility activation schedule and project cost analysis were briefly outlined.

And in Section Four, the Research Plan was presented as an interrelated series of work areas, with major projects within each area listed to more specifically indicate the kinds of studies being planned. The six work areas were:

Work Area	
100	Emission Inventories
200	Atmospheric Transformations
300	Atmospheric Structure and Dispersion
400	Removal Processes
500	Mathematical Simulations
600	Control Economics

Copies of the report and additional information may be obtained by contacting Francis Pooler, Jr., Principal Investigator.

Publication

Pooler, F. Regional Air Pollution Study, No. 1 Study Plan. Environmental Protection Agency, Research Triangle Park, North Carolina. October 1972 (revised April 1973).

2.2.2 RAPS WORK PLAN

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-1081, Task Order No. 1

Period of Performance May - September 1973

Summary

This Task Order was originated as the first of three to assist the EPA in developing the Contractor/RAPS staff interface to implement RAPS activities. Objectives of this Task Order included developing a work plan to cover field experiments and other tasks required during the fiscal year 1974 to achieve RAPS Study Plan objectives; and making recommendations to the RAPS Field Director regarding future tasks to be performed by the RAPS contractor.

In achieving these objectives, meetings with key Rockwell and EPA personnel were held in St. Louis and at Research Triangle Park, devoted to the development of plans to implement the RAPS expeditionary activity. As a result, several suggestions were submitted to the EPA for developing the RAPS plan through fiscal years 1974 and 1975.

Also indicated was the need to involve Rockwell personnel in the development of a detailed RAPS experimental coordination plan extending the earlier RAPS Study Plan (Section 2.2.1). Thus the function of Task Order No. 1 was merged into a new Task Order No. 9 (Section 2.2.3), which called for the construction of a RAPS experimental design.

Copies of the report and other information may be obtained by contacting:

Francis Pooler, Jr. (MD-84)
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(919) 541-2649

Publication

Hidy, G.M. Regional Air Pollution Study. Rockwell International Science Center, Thousand Oaks, California. Task Order No. 1 Final Report, EPA Contract 68-02-1081. April 1974.

2.2.3 RAPS PROGRAM OBJECTIVES AND PLANS

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Funding EPA Contract No. 68-02-1081, Task Order No. 9

Period of Performance November 1973 - June 1974

Summary

Task Order No. 9, continuing efforts begun during Task Order No. 1 of this contract (Section 2.2.2), called for the development of a detailed RAPS experimental coordination plan extending and updating the earlier RAPS Study Plan (Section 2.2.1).

The purpose of this resulting plan was to aid the EPA in effectively managing RAPS; in systematically and logically coordinating the laboratory and field programs of RAPS; and in assuring a flexibility in the evolution of the experimental program of RAPS.

This included the coordination and integration of field activities conducted by EPA laboratories, grantees, and contractors for RAPS purposes,

and the evaluation of these plans for duplications, omissions, inconsistencies and other problems.

The broad outline plan for field activities included experiments to be performed, data to be collected, analyses to be completed, and operational schedules and cost estimates through 1977.

The RAPS Structural Plan, presented in Section One of the report, structured the program with an operational classification in terms of four basic elements: model development and evaluation; emission inventories; aerometric measurements; and data management. Objectives, plans and recommendations for each of these principal elements were discussed in detail.

Section Two, Integration and Synthesis of the RAPS Elements, discussed the logical relationships between RAPS elements and principal program objectives (validated models); operational procedures for the conduct of field expeditions; scheduling requirements; and what elements were missing and/or needed strengthening.

Finally, Section Three, Summer 1974 Field Expeditionary Exercise, presented the schedule of activities for the 1974 summer period and four matrices to allow the RAPS Field Director to continuously monitor the summer 1974 activities. The matrices included: Field Expeditionary Coordination, RAPS Measurement Element Data Classification, Field Expeditionary Measurement Coordination, and RAMS Station Field Expeditionary Utilization.

Copies of the report and additional information may be obtained by contacting the EPA Task Coordinator.

Publication

Burton, C.S., and G.M. Hidy. Regional Air Pollution Study Program Objectives and Plans. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 9 Final Report, EPA Contract 68-02-1081. December 1974. EPA-650/3-75-009.

2.3 RAPS FIELD EXPEDITION PLANNING

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-1081, Task Order No. 50

Period of Performance August 1974 - July 1975

Summary

Recognizing the complexity of RAPS, Task Order No. 50 was initiated to elaborate on the existing Program Plan developed under Task Order No. 9 (Section 2.2.3) and thus provide an updated version based on results to date and to plan the Summer 1975 Field Expedition.

The first of four sections of the report contains the summary and restatement of RAPS purpose and objectives.

Section Two presents an overview to show the role of the Expeditionary Research Program in achieving the goals and objectives of the RAPS.

Details of the Expeditionary Research Program focusing on the Summer 1975 exercise are presented in Section Three. Summaries of experimental designs and plans for the Summer 1975 exercise include schedules, quality assurance plans, logistics and service requirements, site selections, special equipment needs, special data needs, power requirements, potential problems, identification of participants, and interfaces and integration among major RAPS elements, particularly with the RAPS data bank.

Finally, Section Four contains a status report on model evaluation and development, the RAPS data bank, and the emission inventory.

Copies of the report and additional information may be obtained from the EPA Task Coordinator.

Publication

Zegel, W. C. RAPS Expeditionary Research Program. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 50 Final Report, EPA Contract 68-02-1081. July 1975. EPA-600/3-76-016.

2.4 SUMMARY OF RAPS ACTIVITIES

2.4.1 DOCUMENTATION OF RAPS AND RELATED INVESTIGATIONS

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Funding EPA Contract No. 68-02-2093, Task Order No. 122

Period of Performance May 1977 - October 1978

Summary

The original purpose of this task order was to support the RAPS modeling and data management effort by documenting and acquiring data from RAPS related investigations and any other data source that would complement the data base. The task consisted of three subtasks or phases. During Phase I, a survey was to be made of all data collection/measurement activities whether directly or indirectly related to RAPS. The purpose of this survey was to provide the EPA with documentation and an assessment of these activities permitting them to determine the needs and priorities for acquiring these data sets. The second phase was to obtain and reduce, if necessary, these data collections according to the priorities established by the EPA. In order to accomplish this phase, the RAPS Central Computer Facility (CCF) would gradually be converted from real-time data collection to an interactive environment. Phase III required the entire RAPS CCF to be shipped to Research Triangle Park and installed. The CCF was then to be tested and completely demonstrated.

As work progressed on the Phase I survey of available data, the need for a more complete documentation of the RAPS program became apparent. Consequently, the scope of the Phase I report was expanded to document the entire program. More specifically, the report was expanded to document those activities whose data had already been incorporated into the RAPS Data Bank as well as those activities which did not generate any data.

As the RAPS program entered into its final stages, economic considerations required revision of the task order. The Phase I report, which had become the primary product of the task, remained essentially the same, while the requirement for data collection and reduction in Phase II was deleted. Phase III was accomplished as planned.

The final report for Phase I was submitted to the EPA Project Officer. Copies of the report and additional information may be obtained from the EPA Task Coordinators.

Publication

Strothmann, J. A. Documentation of the Regional Air Pollution Study (RAPS) and Related Investigations in the St. Louis Air Quality Control Region. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 122 Final Report, EPA Contract 68-02-2093. August 1979.

2.4.2 PUBLICATIONS AND PRESENTATIONS

During the course of the Regional Air Pollution Study, numerous papers were presented at various conferences and published in several journals and environmental magazines. In addition to those cited on the previous pages, the following group of papers provide special insight or present an overview of the Regional Air Pollution Study:

Allen, P. W. How Good and Useful are Air Pollution Models? Environmental Science & Technology, 7 (7):598-599, 1973.

Allen, P. W. Regional Air Pollution Study - An Overview. Paper No. 73-21 presented at the 66th Annual Meeting of the Air Pollution Control Association, Chicago, Illinois. 1973.

Pooler, F., Jr. Network Requirements for the St. Louis Regional Air Pollution Study. Journal of the Air Pollution Control Association, 24 (3):228-231, 1974.

Pooler, F., Jr. The St. Louis Regional Air Pollution Study: A Coherent Effort Toward Improved Air Quality Simulation Models. Presented at the Summer Computer Simulation Conference, Houston, Texas. July 1974.

Schiermeier, F. A. A Regional Study of the Atmospheric Pollution of St. Louis. Paper presented at the International Congress of the Environment, Paris, France. December 1976.

Schiermeier, F. A. Air Monitoring Milestones: RAPS Field Measurements Are In. Environmental Science & Technology, 12 (6):644-651, 1978.

3.0 REGIONAL AIR MONITORING SYSTEM (RAMS)

Introduction

One of the primary objectives of RAPS was to create a comprehensive, accurate and readily retrievable data base for all criteria pollutants and selected non-criteria pollutants for use in developing and evaluating air quality simulation models. As a major part of the RAPS field measurement program, the Regional Air Monitoring System (RAMS) was designed to provide continuous surface based aerometric measurements for this data base. RAMS consisted of twenty-five remotely operated, automated stations controlled and polled via telemetry by a central data acquisition system. The locations of these stations, shown in Figure 1, were arranged in approximate concentric circles with average radii from the central urban station of 5, 11, 20, and 44 kilometers. Station elevations were fairly uniform averaging 154 ± 23 meters above mean sea level. The stations were clustered at the center of the network as the criterion for site locations required minimum spacing where the concentrations and gradients were highest. The four rural sites spaced at approximately 90° azimuth were situated so as to provide background measurements regardless of wind direction.

Each RAMS station (Figure 2) consisted of a shelter, tower, fence, sensors and support equipment. The metal shelter was 4.9 m wide x 3.3 m deep and 2.7 m high. Towers were erected on the northern side of each station to serve as meteorological equipment stands. Seventeen stations had 30 m towers while the other eight had 10 m towers. Every station was surrounded by a 2 m high chain link fence.

There were three major categories of instrumentation within each RAMS station: pollutant analyzers and collectors, meteorological sensors, and test/control systems.

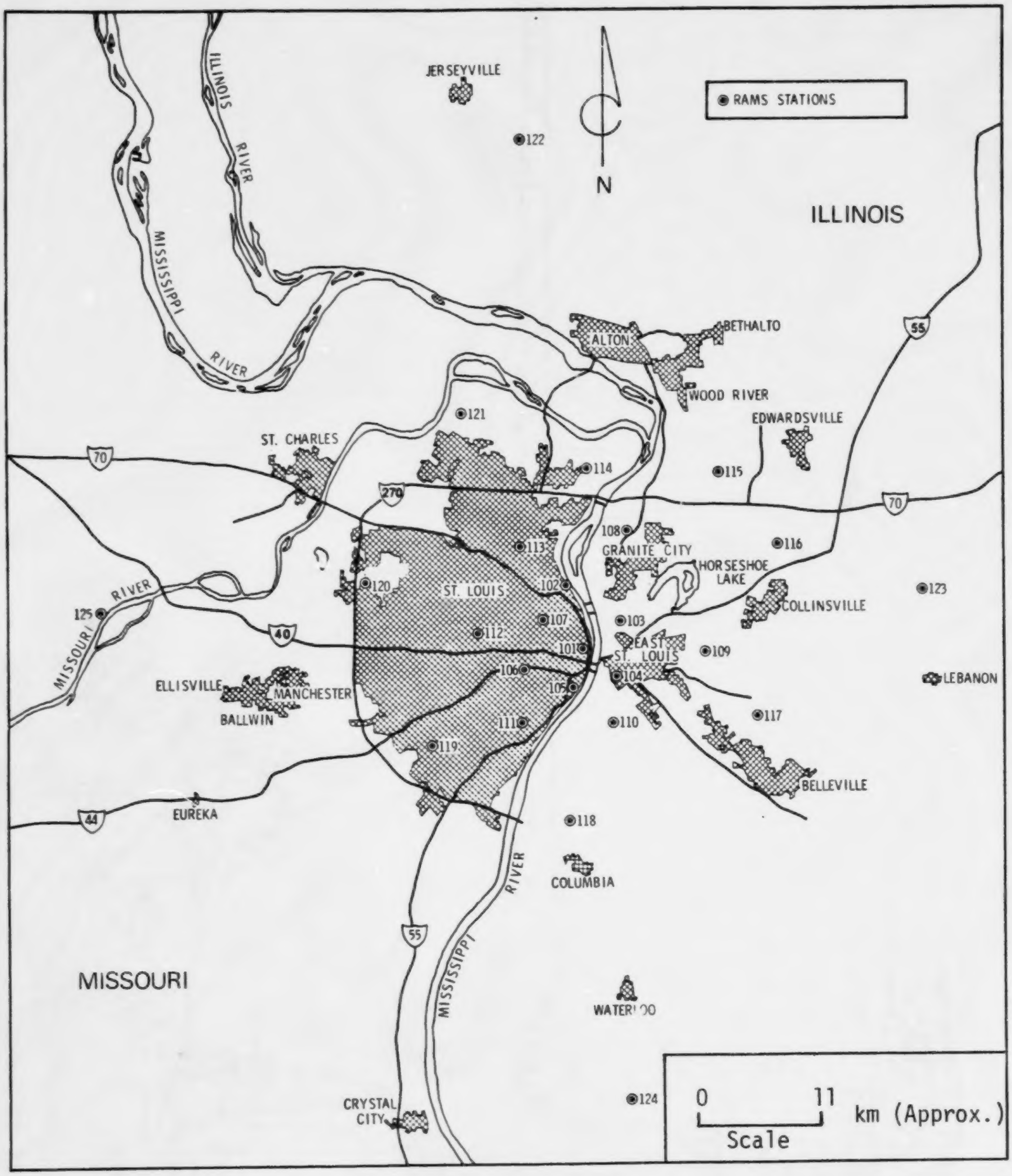

FIGURE 1. LOCATION OF THE REGIONAL AIR MONITORING SYSTEM (RAMS) STATIONS

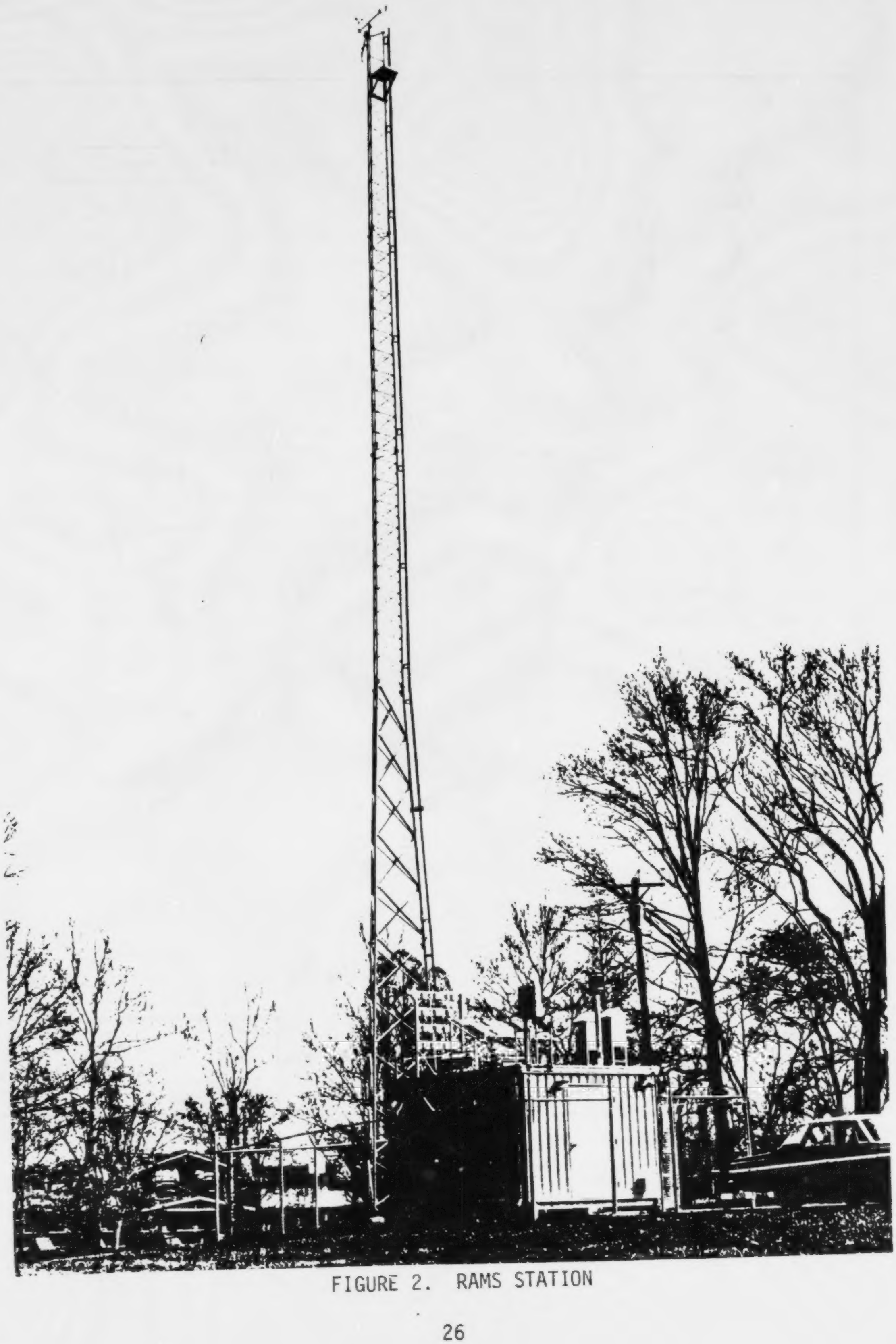

FIGURE 2. RAMS STATION

Each RAMS station was equipped with four gaseous pollutant analyzers to measure ozone, nitrogen oxides, sulfur gases and carbon compounds. All pumps were removed from the gas analyzers prior to installation in the system thereby eliminating their characteristic noise and failure problems. Replacing these pumps were a common vacuum pump and compressor-dryer assembly. The single stage oilless compressor supplied pressurized air to a heatless dryer equipped with two identical desiccant chambers packed with molecular sieve and charcoal. Each chamber acted as a desiccant and hydrocarbon absorber. The chambers alternated with one being regenerated while the other dried the air. In addition to drying, ozone, sulfur dioxide, hydrogen sulfide and oxides of nitrogen were removed so that a continuous stream of ultrapure air could be provided to the analyzers.

Ambient air samples for the gaseous pollutant analyzers were collected at a height of 1.5 m above the roof of the RAMS station or 4.6 m above the ground. Collection was by means of an inverted glass funnel attached to a 76.2 mm I.D. glass tube. The intake funnel and tube were covered with a metal shield for protection. The tube was connected to a horizontal glass manifold of the same diameter inside the station. Each analyzer was able to sample air from this manifold via Teflon tubing. The two gas bag samplers also sampled from this common manifold. A Teflon filter, 6.3 mm mesh, was placed over the bottom of the intake funnel with glass traps at each end of the manifold. Ambient air was transported through the manifold by a blower (2800 liters per min.) located at the end through which the air was exhausted to the outside.

A calibration system for the gaseous analyzers provided a zero and upscale concentration of various gases. Two mass flow meters were used to measure the diluent and calibration mixture. Zero air supplied by the compressor-dryer assembly was additionally purified by passage through a catalytic oxidizer for removal of carbon monoxide and was used as the diluent and for determining instrumental zero. The calibration gases were then mixed in a chamber and delivered to an open ended manifold which allowed the instrument to be fed calibration gas on demand with excess gas vented. The calibration system allowed accurate dilution of calibration sources in ratios up to 1500 to 1 although a nominal value of 500 to 1 was used during the execution of automatic calibration. The calibration system could be controlled automatically by computer or operated manually.

The air sample exhaust manifold provided the exit from the gas sample manifold as well as the exhaust provisions for the outputs from the hydrogen generators and chromatographs. The calibration exhaust manifold provided the exit from the calibration manifold as well as the exhaust provisions for the outputs from the hydrogen sulfide and sulfur dioxide permeation tubes and the ozone generator. An in-line acid gas trap contained four acid gas filters which absorbed contaminants that could have biased the monitoring systems, before expelling the exhaust gases into the ambient air. Ethylene was removed by a heater which oxidized it to carbon dioxide and water.

Most of the meteorological instrumentation was mounted on the station tower. The only exceptions were the solar radiation equipment, the dew point sensor and the barometric pressure sensor. The solar radiation instruments were mounted on their respective stands atop the shelter. The dew point sensor was mounted within the station and sampled from a specially designed inverted funnel which was mounted on the side of the shelter approximately 1.8 m above the ground. The barometric pressure sensor was also mounted on the exterior station wall.

The high volume suspended particulate samplers were mounted on the station roof while the nephelometer and dichotomous sampler were located inside the shelter. The nephelometer and dichotomous sampler utilized a specially designed aluminum intake manifold. The intake was designed to insure the entry of particles from the air stream for delivery to the analyzer. The intake had a conical cover to simulate the particle size censoring of the standard hi-vol.

The following is a summary of the RAMS network including the equipment and analyzers used, quality assurance activities, data acquisition and data availability.

3.1 RAMS NETWORK

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Funding

EPA Contract No. 68-02-1080
EPA Contract No. 68-02-2093, Exhibit A

Period of Performance

Contract No. 68-02-1080. May 1974 - August 1975
Contract No. 68-02-2093. August 1975 - July 1978

Parameters Measured	Instrument/Method Used
Ozone*	Monitor Labs Model 8410A chemiluminescent analyzer with an effective measurement height of 4 meters. The range was selectable with 0-.20 ppm normally used and 0-.50 ppm used during the oxidant season. The nominal span value was 0.10 ppm. Minimum detection limit was 0.005 ppm.

*Although manufacturer's specifications varied, the EPA requirements for these five gaseous analyzers included allowable zero drift of 2% per day and allowable span drift of 5% per day.

Parameters Measured	Instrument/Method Used (continued)
Oxides of Nitrogen*	Monitor Labs Model 8440 chemiluminescent analyzer measuring both NO and NO_X continuously with an effective measurement height of 4 meters. NO_2 was determined by differencing the two measurements. The range was selectable with 0-.50 ppm used. The nominal span value was 0.10 ppm. Minimum detection limit was 0.005 ppm.
Hydrocarbons and Carbon Monoxide*	Beckman Instrument Model 6800 gas chromatograph with an effective measurement height of 4 meters. The range for carbon monoxide was automatically selected being either 0-10 ppm or 0-50 ppm; the range for methane and total hydrocarbons was selectable at 0-10 ppm or 0-25 ppm.
Sulfur Dioxide and Total Sulfur*	Tracor Inc. Model 270 HA chemiluminescent analyzer with an effective measurement height of 4 meters. Simultaneous ranges of 0-.2 ppm and 0-1.0 ppm were used for total sulfur and sulfur dioxide while 0-.1 ppm and 0-1.0 ppm were used for hydrogen sulfide. Minimum detection limit was 0.005 ppm.
Total Sulfur*	Meloy Laboratories Model SA-185 chemiluminescent analyzer with an effective measurement height of 4 meters. The range was automatically selected to either 0-.2 ppm or 0-1.0 ppm. Minimum detection limit was 0.005 ppm.

Parameters Measured	Instrument/Method Used (continued)
Light Scattering Coefficient	Meteorology Research Inc. Model 1561 nephelometer with an effective measurement height of 5 meters. Range was set at 0.1 to 10 x $10^{-4}m^{-1}$ with an accuracy ± 10% of scale. A flow rate of .0024 m^3/s was used.
Wind Speed	Meteorology Research Inc. Model 1022S three cup anemometer with an effective measurement height of 10 or 30 meters depending on tower height. The range was 0.22 to 22.35 m/s with a starting threshold of 0.22 m/s and accuracy of ± 0.067 m/s or 1% (whichever is greater).
Wind Direction	Meteorology Research Inc. Model 1022D wind vane with an effective measurement height of 10 or 30 meters depending on tower height. Range was 0-540° with a starting threshold of 0.3 m/s. The damping ratio was 0.4 at 10° angle of attack. Linearity was ± 0.5% of full scale and resolution was 0.1%.
Temperature	Meteorology Research Inc. Model 840-1 dual thermistor and resistor network with an effective measurement height of 5 meters. Range was -20°C to + 50°C accurate to ± 0.05°C.
Dew Point	EG&G International Model 880 optically sensed, thermoelectrically cooled, condensation dew point hygrometer with an effective measurement height of 2 meters. Range was from -40°C to +50°C with a maximum depression capability of 45°C at an ambient temperature of 27°C.

Parameters Measured	Instrument/Method Used (continued)
Dew Point (continued)	Resolution was 0.25°C with a nominal accuracy of 1°C.
Temperature Gradient	Meteorology Research Inc. Model 840-1/840-2 thermistor and resistor networks with an effective measurement height of 5 and 30 meters. The range was -5°C to +5°C with a ± 0.1°C accuracy.
Barometric Pressure	Meteorology Research Inc. Model 751/YSI Model 2014 transducer incorporating several diaphragms of NiSpan C alloy with an effective measurement height of 2 meters. The range was 27.0-31.5 inches of Hg (947 - 1080 mb) with resolution of 0.2% of full scale. Linearity was ± 0.3% of full scale.
Solar Radiation	Eppley Laboratory's precision spectral pyranometer, normal incidence pyreheliometer and precision infrared radiometer (pyrgeometer) with an effective measurement height of 5 meters. The range was 0-4 cal cm^2/min with a sensitivity of 5 mv per cal cm^2/min. Temperature dependence was ± 1%.
Turbulence	R. M. Young Model 27002 Gill UVW Anemometer with an effective measurement height of 30 meters. The operating range was 0.22 to 22 m/s with a threshold of 0.22 m/s. Response was one revolution per 30 centimeters of air movement.
Gas Bags	Xonics Inc. bag sampler utilizing 100 liter Teflon and Tedlar bags with an

Parameters Measured	Instrument/Method Used (continued)
Gas Bags (continued)	effective measurement height of 4 meters. Flow rate could be controlled from 0-1200 cc/min by a regulator.
Total Suspended Particulates	Sierra Instruments Model 305 high volume sampler with an effective measurement height of 4 meters. A 20 x 25 cm glass fiber filter was used with a flow rate of 0.02 m^3/s which was continuously controlled by a Sierra Instruments Model 320 flow controller.
Total Suspended Particulates (fractionated)	Lawrence Berkeley Labs (LBL) automatic dichotomous air sampler collecting particulates in two size ranges, less than and greater than two micrometers. The size segregation technique incorporates a two stage virtual impactor with an automatic velocity control system. Samples were collected on cellulose acetate filters.

The distribution of these instruments at the RAMS stations is shown in Table 1.

Calibration and Quality Control Procedures

Gas Analyzers

Calibrations were performed on each of the RAMS station gaseous pollutant analyzers once every twenty-four hours for every pollutant except hydrogen sulfide as measured by the Tracor Sulfur Gas Chromatograph. This component was calibrated only during the manually executed multipoint calibrations. The automatically executed calibrations were carried out between the hours of 2000 and 2400 CST each day. These daily calibrations were performed utilizing the station calibration system under the command of the station data acquisition system (DAS). The station DAS in turn received its commands to carry out each calibration from the Central Computer. Each automatically executed

TABLE 1. RAMS REMOTE STATIONS INSTRUMENT DISTRIBUTION

		101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
O_3 - Monitor Labs 8410		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NO - NO_X Monitor Labs 8440		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CO - CH_4 - THC Beckman 6800		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TS - SO_2 -H_2S Tracor 270HA		X		X	X	X	X		X					X	X	X	X				X	X	X			
TS - Meloy SA 185			X					X		X	X	X	X					X	X	X				X	X	X
Visibility -MRI 1561		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wind Speed - MRI 1022 S		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wind Direction -MRI 1022 D		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Temperature - MRI 840-1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dew Point - Cambridge 880		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Temp. Gradient - MRI 840-2		X	X		X	X	X	X		X		X	X	X									X	X		
Barometer - MRI 751/YSI 2014		X								X			X										X	X	X	X
Solar Radiation (Eppley)	Pyranometer			X	X				X						X				X				X			
	Pyrheliometer			X											X				X				X			
	Pyrgeometer			X											X				X				X			
Turbulence - R. M. Young 27002						X		X		X		X		X												
Gas Bags - Xonics		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hi - Vol, Sierra 305				X		X	X		X				X			X			X		X		X		X	
LBL Dichotomous Sampler				X		X	X		X				X			X			X		X		X		X	
10 Meter Tower									X		X				X	X	X	X	X			X				
30 Meter Tower		X	X	X	X	X	X	X		X		X	X	X						X	X		X	X	X	X

calibration consisted of a zero and one upscale point in the normal operating range. Those instruments which were capable of being range-changed were automatically locked into low range during calibration by the station DAS. Each instrument zero was determined by introducing zero air into the calibration manifold and obtaining the instrument sample input from this manifold.

The RAMS gas analyzer calibration system was designed to dynamically dilute concentrated calibration sources with air which had been scrubbed of water and all pollutants. Two mass flow gas metering devices were used to measure the diluent and calibration mixture. These gases were mixed in a chamber and delivered to a manifold into which sample lines to each instrument were fed through valves which allowed either the ambient air or calibration manifold connection to be made. This manifold was also open-ended, allowing the instrument to be fed the calibration gas on demand with excess gas vented. This circumvented any difficulties arising from pressure inequalities between ambient and calibration sample sources for the instruments.

The precise measurement of flow afforded by the mass flow meters and the use of only inert materials (glass and Teflon) in the calibration system allowed accurate dilution of calibration sources in ratios of up to 1500 to 1 in the calibration system. A nominal dilution ratio of 500 to 1 was used during the execution of automatic calibrations.

The station zero air generation system consisted of an oilless compressor whose output passed through a "heatless dryer" which consisted of two regenerable scrubber columns containing a mixture of molecular sieve and charcoal. This scrubber effectively removed all reactive pollutants from the ambient air as well as water and a substantial fraction of the carbon dioxide normally present. It did not, however, remove enough methane and carbon monoxide to meet zero air requirements for the Beckman 6800. For this reason a catalytic oxidizer (MSA) was switched into the zero air delivery system during the Beckman 6800 zero and span. This switching was necessary because the catalytic oxidizer had been found to introduce small quantities of NO_2 into the zero air due to an unknown chemical reaction or bleed off from the catalyst beds, therefore making the flow of zero air through this unit at all times impractical.

The upscale point for each instrument was achieved by introducing the appropriate calibration gas into the mixing chamber with the zero air used as the diluent.

The remote station computer was programmed to execute these zero and span sequences for each instrument in such a way as to allow for instrument settling times before data were acquired representing zero, span and ambient values. Multiple data points were acquired for both zero and span and these values were averaged by the Central Computer to determine the voltage levels to be used in the computation of the calibration constants. The remote station data acquisition system suppressed data from the appropriate slots during instrument settling times. These times and the number of data points used to determine zero and span values varied with each instrument.

In addition to the daily automatically executed zero and span calibrations, each station gas analyzer was subjected to a manually executed multipoint calibration at approximately ten week intervals.

Multipoint calibration activity started with calibration of the mass flow meters in the station calibration system by means of a positive displacement bubble type device, verification of permeation tube temperature, and verification of zero air cleanliness. After completion of these system verification tasks, the field engineer then used the station calibration system to introduce zero air and five different upscale concentrations of calibration gas into each gas analyzer on each of the normal operating ranges and those ranges which could be used via auto-ranging capability. The data obtained was plotted (concentration vs. voltage output) and the linearity and sensitivity (volts of instrument response per ppm of pollutant input) of the analyzer were determined. Required maintenance and adjustments were then made and the calibration replotted if problems were discovered. Strip chart recorders were used to determine the signal quality from each instrument and repairs or replacements were made as dictated by examination of these records. At the time of the multipoint calibration, cylinders of calibration gases of approximately the same concentrations as the station calibration sources were swapped with the station calibration cylinders and comparative values were obtained. The cylinders used for this activity were secondarily traceable to an NBS Standard Reference Material cylinder for the same pollutant. The pollutant concentration of the station cylinder as determined by this comparative test was then updated in the central computer calibration file. Station cylinders whose concentration required adjustment of more than 10% of the stated value were deemed unstable and were replaced with new cylinders which had been certified against NBS standards. All replacements of station cylinders after August 1976 were made with aluminum cylinders because of their improved stability over steel cylinders.

Corrective maintenance represented another type of field activity with the gas analyzers. Based on examination of calibration data from the evening period and real-time messages from the central computer, field personnel were deployed on a demand basis to correct problems. An automatic calibration was usually initiated by the attending individual if maintenance was performed on a gas analyzer which was reporting invalid data.

Preventive maintenance visitations to RAMS stations were scheduled twice per week. Preventive maintenance consisted of replenishing those parts of the gas analyzer and support system which were required as scheduled. These items of replenishment and other system operating parameters which were checked as part of preventive maintenance are illustrated in Table 2.

Calibration Standards

The following is a brief description of the calibration standards used for each of the RAMS analyzers.

Nitrogen Oxides

A steel cylinder of approximately 100 ppm nitric oxide in nitrogen was used as the station calibration standard for nitrogen oxides. Gas phase titration also allowed this source to be used as the standard for ozone and nitrogen dioxide as well.

Nominal span values used during automatic daily calibration are 0.2 ppm for NO and 0.1 ppm for NO_2.

Sulfur Dioxide Gases

A Standard Reference Material sulfur dioxide permeation tube from the National Bureau of Standards was used as the source for the calibration of both total sulfur and sulfur dioxide. The hydrogen sulfide components of the Tracor sulfur gas chromatograph were calibrated occasionally with a vendor

TABLE 2. PREVENTIVE MAINTENANCE TASKS

DESCRIPTION OF PREVENTIVE MAINTENANCE ITEMS	TIMES PER YEAR
RAMS Station Checkout	104
Control "P" Status Check	104
Clean and Check Tape Recorder	12
Service Teletype	3
Clean Control and Status Panel	2
Inspect Sample Panel Lines	52
Inspect Calibration Manifold	52
Inspect Mixing Chamber	3
Inspect Ozone Generator	3
Check Permeation Tube Water Bath	104
Check Water Bath Temperature	104
Adjust Dilution Air Flows	As Required
Check Permeation Tube Levels	26
Calibrate Mass Flowmeter MF-1C	10
Calibrate Mass Flowmeter MF-1G	10
Replace Gas Cylinders	As Required
Adjust Cylinder Panel Pressures and Flows	26
Adjust Vacuum Panel Pressures and Flows	26
Adjust Pressure Panel Pressures	26
Clean Vacuum Manifold Filters	12
Replace Hydrogen Molecular Sieve	3
Fill Hydrogen Generator Reservoirs	52
Leak-Check Hydrogen Generator	26
Inspect NO-NO$_X$ Analyzer Lines	52
Inspect Ozone Analyzer Lines	52
Inspect Sulfur Analyzer Lines	52
Check Sulfur Analyzer Temperatures (Tracor)	104
Change Sampling Manifold Filters	26
Clean Sampling Manifold Glassware	12
Replace Vacuum Pump Filters	12
Replace Vacuum Pump Vanes	6

(continued)

TABLE 2. (continued)

DESCRIPTION OF PREVENTIVE MAINTENANCE ITEMS	TIMES PER YEAR
Drain Surge Tank	26
Replace Compressor Intake Filters	12
Replace Dryer Desiccant Chambers	As Required
Clean Dryer Check Valve	As Required
Clean Pressure Relief Valve	12
Clean Pump Box	12
Replace Pump Box Filters	26
Lubricate Pump Box Blower Motors	6
Lubricate Air Conditioner Motors	2
Replace Air Conditioner Filters	2
Clean Air Conditioner Coils	1
Check Air Conditioner Water Drain	3
Replace Nephelometer Air Filter	52
Clean Hygrometer Mirror	104
Replace Hygrometer Inlet Filter	52
Clean Pyranometers	104
Clean and Adjust Pyrheliometer	104
Check Solar Radiation Blower and Air Flow	104
Check Solar Radiation Desiccant	104
Clean Pyrgeometer	104
Check Pyranometer Levels	12
Check Pyrgeometer Level	12
Check Moisture Inside Radiation Sensors	104
Inspect Tower and Instruments	52
Calibrate Wind Instruments	2
Clean Ambient Temperature Sensor	2
Calibrate Ambient Temperature Sensor	2
Calibrate Vertical Temperature Gradient	2
Calibrate Barometric Pressure Sensor	As Required
Oxides of Nitrogen Calibration	10
Ozone Generator Calibration	10

(continued)

TABLE 2. (continued)

DESCRIPTION OF PREVENTIVE MAINTENANCE ITEMS	TIMES PER YEAR
Ozone Analyzer Calibration	10
Sulfur Analyzer (Meloy) Calibration	10
Sulfur Analyzer (Tracor) Calibration	10
Air Quality Chromatograph Calibration	10
Perform Nephelometer Fluoro-hydrocarbon Calibration	4
Replace Nephelometer Bulb	6
Clean Computer Ventilation Filters	4

calibrated permeation tube. Both permeation tubes were maintained in a thermostated environment at 30°C ± 0.1°C by means of a carefully regulated water bath. A 30 cc/min flow of zero air was used to transport the effluent of the SO_2 permeation tube to the calibration system for dilution to the correct concentration. Nitrogen was used to transport the H_2S output to the dilution system. The permeation tubes used in RAMS were a two centimeter standard rate tube for SO_2 and a one centimeter standard rate tube for H_2S.

The automatically executed calibration span value of the sulfur gas analyzers with SO_2 was nominally 50 to 70 ppb, dependent, of course, on the permeation rate of the SO_2 permeation tube.

Ozone

The calibration source for ozone was a generator consisting of a 9 inch pencil shaped ultraviolet lamp over which zero air was passed, converting a small portion of the oxygen to ozone. This lamp was equipped with an adjustable cylindrical shield, allowing fine tuning of the generator output.

The ozone generator was adjusted to yield a nominal 0.1 ppm concentration after dilution during the daily automatic span calibration of the ozone instrument.

The amounts of ozone generated by this lamp were determined by gas phase reaction with nitric oxide according to the following mechanism.

$$NO + O_3 \rightarrow NO_2 + O_2$$

The nitrogen oxides analyzer was used to determine the reduction in NO concentration after introduction of the ozone generator output into the calibration system mixing chamber. Immediately thereafter, the diluted ozone generator output was used to calibrate the ozone analyzer. This was performed as soon as possible after the gas phase reaction because the ozone generator stability over long periods of time was not good.

The automatically executed gas phase titration with a nominal starting concentration of 0.2 ppm for NO and the ozone generator set to deliver 0.1 ppm yielded approximately a 50% reduction in the NO concentration. These conditions provided for a large enough change in NO concentration for that change to be measured with good accuracy while not causing the nitric oxide - ozone ratio to be such that higher oxides of nitrogen were formed, thus causing the reaction to be non-stochiometric.

Carbon Monoxide and Hydrocarbons

A steel cylinder containing a compressed gas mixture of carbon monoxide at a nominal concentration of 5000 ppm and methane at a nominal concentration of 2500 ppm in nitrogen was used as a calibration source for carbon monoxide, methane and total hydrocarbons. This mixture was diluted to the appropriate concentration in the station calibration system.

Meteorological Sensors

Preventive maintenance, quality assurance audits and recalibrations were performed on all meteorological sensors located at the RAMS remote stations, once every six month. Corrective maintenance was performed on demand and constitutes the major effort for these instrument systems.

Corrective maintenance activities were requested as a result of examination of hourly average Level I voltage values for the meteorological parameters as they were reported by the Central Computer. Sensor anomalies were usually easily detected by interstation comparisons of these values. This allowed the timely dispatching and correction of most problems within 24 hours.

Quality assurance audits were performed on the meteorological sensors at six month intervals concurrent with preventive maintenance and calibration activities. The procedures used for quality assurance are briefly outlined below. Each procedure was carried out prior to recalibration of the instrument.

Wind Speed - A motor of one known rotational speed was connected to the sensor shaft and the voltage as measured by the data acquisition system was reported.

Wind Direction - Vane was normally oriented by sighting on a nearby target whose bearing from the station has been accurately determined. The voltage as measured by the data acquisition system was reported.

Outside temperature - Sensor was immersed in an agitated water bath along with an NBS certified thermometer. Signal level as reported by data acquisition system was recorded. This was done typically for a subambient temperature nominally at 0°C, a point approximating ambient at nominally 20°C to 25°C, and a superambient point of 35°C to 40°C.

Dew Point - Dew point as reported by instrument and an aspirated psychrometric instrument were compared.

Differential Temperature - Both upper and lower probes were immersed in agitated water baths of equal and unequal temperatures and the signal output for each case was recorded. An NBS certified thermometer was used to determine the bath temperatures.

Turbulence - A constant speed motor was used on each of the three generators in much the same fashion as with the wind speed.

Barometric Pressure - The barometric pressure sensors were compared to a Negretti-Zambra precision aneroid barometer about every eight months. Annually, the sensors were removed along with their electronic cards and compared to an NBS-traceable Bell & Howell barometer at the AVSCOM meteorology laboratory at the U.S. Army Granite City Depot.

Solar Radiation Sensors - Solar radiation sensor quality assurance for RAMS consisted of side-by-side operation of station instruments with an independent set of standard instruments. Data collected from the standard instruments were acquired by a data logger with a zero to twenty millivolt acquisition capability, thereby eliminating the necessity for the amplifiers used for the station instruments. The data logger recorded the magnitude of the signals acquired on punched paper tape with one data value per instrument recorded each minute. The paper tape was then returned to the Central Computer, where it was read and the values compared to those obtained through the station data acquisition system and telecommunication to Central. A comparative report was then generated indicating differences between the two systems.

The standard set of instruments was resident at each site for a period of one month, allowing an audit of all radiation sensing stations once every six months. The standard instruments were returned to the EPA laboratories after each complete audit for recalibration.

Suspended Particulate Samplers

Integrating Nephelometer - Calibration of the nephelometer was accomplished by introducing first clean air, then Freon-12 into the sample chamber. The Rayleigh scattering of these two gases was used to adjust the instrument to preset values. This calibration was accomplished on the nephelometers in the RAMS remote stations once every three months or sooner if burnout of the quartz-halogen lamp occurred.

Quality control for this instrument consisted of determination of the reported scattering coefficient for clean air and Freon-12 before instrument adjustment at the time of calibration.

High Volume Filter Samplers - Quality assurance checks on the hi-vol samplers consisted of auditing the flow calibration through the use of a top loading standard orifice and precision oil manometer. These quality assurance checks were performed every six months.

Automatic Dichotomous Air Sampler - Flow calibrations were checked with flow meters that had been calibrated at Lawrence Berkeley Laboratories. The vacuum pressure of the pump was also checked and the vacuum pump vanes replaced when the pressure fell below 25" Hg.

Data Acquisition and Computer Systems

Each RAMS station had an extensive data acquisition system as one of its main components. At the heart of the data acquisition system was the Digital Equipment Corporation PDP-8M mini-computer. The PDP-8 had the following options: power fail and automatic restart, a real time clock, the extended arithmetic element and two asynchronous interfaces. In addition to the normal 8k, 12 bit words of memory which came with the PDP-8, another 8k were supplied. In normal operation, the data acquisition system communicated its data in real time to the Central Computer Facility (CCF). However, back-up storage was provided at each station. This storage was an industry-compatible magnetic tape, 9 channel, 800 bits per inch, Pertec Magnetic Tape Unit, Model 7830-9. To get the analog data into the system it was necessary to install a multiplexer, analog-digital converter system. The unit chosen for this application was a Xincom Model 3150. Also included in the data acquisition system was a Teletype for displaying data and communication with the system for the operator.

A six digit, digital display was present for displaying time or the value of any analog channel in the system.

The Central Computer Facility of RAMS was the real time focal point for all data and operations. Data were received from the stations at one-minute intervals via four leased phone lines and Novation modems running with Bell 202 type compatibility.

The central computer for RAMS was originally two computers; hardware interleaved and running in tandem. The first computer was a small PDP-11/05 with 16k, 16 bits words of memory, a Teletype, and four asynchronous interfaces. The 11/05 was hooked through a Unibus window to the larger PDP-11/40 with 40k words of memory, and the majority of the system peripherals including discs, tapes, printer-plotter, line printer, card reader and cathode ray tube and operator's console. The PDP-11/05 was in charge of real time data handling and as such was the master of the system. The PDP-11/40 was used primarily to do background processing, but with the stipulation that its peripherals were used by the PDP-11/05 in real time on an as required basis. A PDP-11/35 was subsequently added to the system to provide additional capability for reprocessing of previous RAMS measurements. The 11/35 was configured in a similar manner as the 11/40.

Basically the performance characteristics of the peripherals were as follows: each disc unit has 1.2 million-16 bit words of storage. The tape drives were nine track, 45 ips, 800 bpi with the exception of one drive which was 7 track at multiple density. The line printer printed a full 132 columns, 300 lines per minute minimum print speed. The electrostatic printer-plotter printed in excess of 4000 lines per minute and could generate a two dimensional or three dimensional plot in about three seconds, providing the computations had been done in advance. The card reader operated at about 300 cards per minute. The cathode ray tube display (ADDS 880) was a standard unit with keyboard.

Periods of Data Collection

With the exception of the high volume gas bag and automatic dichotomous samplers, the RAMS system collected ambient data from 25 stations on a minute by minute basis, 24 hours per day. These minute values represented minute averages based on 120 1/2-second readings. Each of the RAMS stations produced a complete data record every minute. These data records contained the station identification number (101-125), the data record time including year, day, hour, and minute, the minute average values (of half-second readings), and the status words for that minute. The high-volume samplers obtained a 24-hour sample every 3 days. The gas bag samplers were activated on an as-required basis. The automatic dichotomous samplers collected a sample every 2 to 12 hours depending on their location and their special study status.

Stations within the RAMS network came on-line over a period of several months beginning with Station 115 on June 2, 1974. The exact periods of station operation are shown in Table 3.

TABLE 3. RAMS STATION OPERATIONAL PERIODS

Station	Start	Stop	Station	Start	Stop
101	8/15/74	3/31/77	114	8/20/74	3/31/77
102	6/28/74	3/31/77	115	6/2/74	6/30/77
103	6/24/74	3/31/77	116	7/21/74	3/31/77
104	8/20/74	6/30/77	117	7/9/74	3/31/77
105	8/2/74	3/31/77	118	7/26/74	3/31/77
106	4/22/74	6/30/77	119	9/4/74	3/31/77
107	8/28/74	6/30/77	120	8/27/74	3/31/77
108	8/2/74	3/31/77	121	7/26/74	6/30/77
109	6/29/74	3/31/77	122	8/9/74	3/31/77
110	8/21/74	3/31/77	123	8/7/74	2/12/77
111	8/26/74	6/30/77	124	7/24/74	2/12/77
112	8/26/74	3/31/77	125	7/14/74	6/30/77
113	6/24/74	3/31/77			

Location of Information Concerning Data Collection

Additional information concerning data collection may be obtained from the EPA Project Officer.

Location and Type of Data Available

RAMS data are generally available in edited form for the period of January 1, 1975 through March 31, 1977 except for Stations 123 and 124 which ceased operations on February 12, 1977. Seven RAMS stations remained in operation through June 1977. Data may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Pooler, F. Jr. Network Requirements for the St. Louis Regional Air Pollution Study. Journal of the Air Pollution Control Association, 24(3):228-231, 1974.

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Hern, D. H. and M. H. Taterka. Regional Air Monitoring System Flow and Procedures Manual. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. EPA Contract 68-02-2093. August 1977.

Hern, D. H., R. T. Jorgen, and J. A. Strothmann. Operation of the Regional Air Monitoring System. Rockwell International Air Monitoring Center, Creve Coeur, Missouri EPA Contract 68-02-2093. In preparation.

3.2 INDEPENDENT RAMS QUALITY ASSURANCE

3.2.1 EPA/HERL PERFORMANCE AUDITS

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Funding Environmental Protection Agency

Period of Performance January 1975

Summary

In order to evaluate the accuracy of the Regional Air Monitoring System, the EPA Health Effects Research Laboratory (HERL; formerly Human Studies Laboratory) provided a four man audit team to independently determine the reliability of the RAMS measurements. During the week of January 19-26, 1975 this team visited the network and performed a quality control audit on nine RAMS stations, the central computer and controller and the gas chromatography laboratory.

The audit consisted of the following tasks:

1. A dynamic multipoint independent calibration of instrument response was performed by injecting a secondary standard pollutant sample into each gaseous sensor.
2. All station calibration gases were assayed by the use of secondary standards.
3. All sensors and auxiliary equipment were inspected and checked for proper hook-up and operation.
4. The contractor's operating procedures were evaluated.
5. The accuracy of the reported data was evaluated.

In performing the audits all gas samples, signal generator and other instrumentation used were either a reference standard which was maintained by the HERL Standards Laboratory or a transfer standard which is referenced to the HERL designated primary standard.

A summary of the audit results for gaseous pollutant analyzers and meteorological instrumentation is shown in Table 4. The central computer was tested by inputting a known voltage through a spare data channel at two field locations and the output was observed on a CRT at the central computer facility. The input and output voltages were essentially the same. The calibration gases used by the gas chromatography were checked by comparing them with HERL standards. The results of the gas cylinder comparison are shown in Table 5. The concentration value of the NO cylinder used by the contractor differed from those found by the HERL team. The discrepancy did account for a known error in the calibration of the NO_X analyzers.

TABLE 4. SUMMARY OF AUDIT RESULTS

Parameter Measured	Method	Average Error Found in Field Stations Calibration (Computed as slope error)	Range of Errors for the 8 Stations Audited
1. Nitric Oxide	Chemiluminescence	12.5%	-5.8% to + 29.2%
2. Nitrogen Dioxide	Chemiluminescence	11.7%	-6.7% to + 29.3%
3. Total Oxides of Nitrogen	Chemiluminescence	12.3%	-5.7% to + 27.4%
4. Sulfur Dioxide	Gas Chromatograph and Flame Photometric	34.8%	-55.2% to -5.3%
5. Hydrogen Sulfide	Gas Chromatograph		
6. Total Sulfur	Gas Chromatograph		
7. Ozone	Chemiluminescence	15.6%	-37.9% to + 14.8%
8. Total Hydrocarbons	Gas Chromatograph	12.8%	-23.9% to -3.6%
9. Methane	Gas Chromatograph	22.1%	-31.3% to -10.5%
10. Carbon Monoxide	Gas Chromatograph	17.2%	-32.0% to -1.5%
11. Nitric Oxide Cylinder Concentration	HSL Calibrator-GPT	24.4%	+49.1% to +6.6%
12. Permeation Tube Water Temperature	Thermistor	0.4°C	-0.7°C to -0.3°C
13. Dew Point	Thermistor	1.8°C	-2.3°C to +5°C
14. Ambient Temp.	Thermistor	0.6°C	-1.6°C to +1.1°C
15. NO_2 Converter Efficiency	15 of 16 tested	greater than	90% efficient
	1 of 16 tested		82% efficient

TABLE 5. GAS CHROMATOGRAPHY LABORATORY CYLINDER COMPARISON RESULTS

Pollutant Calibration	Concentration as Marked on Cylinder (ppm)	Concentration as Determined by HSL QC (ppm)	Error %
Methane - Tank A	7.86	7.56	4.0
Methane - Tank B	5.20	4.66	11.6
Carbon Monoxide - Tank A	8.00	7.32	10.9
Carbon Monoxide - Tank B	41.5	41.5	0.00
Nitric Oxide	Not marked	103	-

Overall the linearity of the RAMS sensors was found to be satisfactory with the exception of the sulfur analyzers. No multipoint calibrations were performed on these analyzers because of their slow response. Consequently, there was no linearity check. Electronics and software appeared to handle the data satisfactorily. It was also recommended that the mass flow controllers and meters should be checked in future audits.

Publication

Burton, R. M., O. L. Dowler, W. M. Kozel, and G. R. Ballard. Quality Control Audit Report: RAMS/RAPS No. 1. Environmental Protection Agency Human Studies Laboratory, Research Triangle Park, North Carolina. February 1975.

3.2.2 RTI PERFORMANCE AUDITS

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Funding

EPA Contract No. 68-02-1772
EPA Contract No. 68-02-2407

Periods of Performance

Contract No. 68-02-1772	May - December 1975
Contract No. 68-02-2407	January 1976 - May 1977

Summary

In order to assure, assess and document the validity of the data generated by the Regional Air Monitoring System, a comprehensive and integrated quality assurance program was initiated by the RAPS Data Manager of the EPA. Under EPA Contract 68-02-1772, Research Triangle Institute (RTI) was to identify and assess the quality control practices and procedures employed in RAMS/RAPS; to recommend changes or additions to these existing practices and procedures as required to develop a comprehensive quality control program; to document the validity of the data generated as part of the RAPS; and to recommend quality assurance procedures to monitor the effectiveness of the quality control program. This independent audit and study of RAPS consisted of three phases. The first phase included an independent on-site/off-site qualitative systems review. The second phase involved conducting a systematic and independent on-site quantitative performance audit.

Finally, the third phase involved making recommendations for additions to or changes in the quality control activities of RAPS based on the information gained in the first two phases.

During the first phase a two part checklist was developed. The first part was directed toward organizational structure, function and/or activities that existed for checking purposes, independent of the remote stations. This portion of the checklist was designed to:

1. Identify existing system documentation, i.e., maintenance manuals, organizational structure, operating procedures, etc.
2. Evaluate the adequacy of the procedures as documented based on RTI personnel experience and applicable historical data from RAMS, if available.
3. Evaluate the degree of use of and adherence to the documented procedures in day-to-day operations based on observed conditions (auditor) and a review of applicable RAMS' records on file.

The second part of the checklist was used for evaluating the remote monitoring stations. The monitoring stations were checked for nominal values and acceptable ranges for the various pressures, flow rates and voltages as specified by the RAMS Remote Monitoring Station Operation and Maintenance Manual.

The overall average rating derived from the first part of the checklist was 2.8 out of 5.0 possible. This rating indicated that some improvements had to be made in order to have an acceptable quality assurance program. (3.0 represented a marginal, but tolerable condition.)

Eight remote stations were checked for the second part of the checklist. The results of these checks revealed that there was uncontrolled or unregulated purging of the ultraviolet lamp housing assembly of the ozone generator; that the calibration gas mixture created 2 to 3% excess nitrogen which caused an estimated error of 5 to 10% in hydrocarbon measurements; that some of the mass flow meters needed recertification; that multipoint calibrations were not performed every five weeks; and that instruction and operating manuals for the data system, air quality analyzers and calibration equipment needed upgrading.

The overall objective of the quantitative performance audit (Phase II) was to collect the information necessary to estimate the current precision and bias of the air pollution and meteorological data generated and subsequently reported by RAMS.

The audit consisted of two main components as follows:

1. Total measurement systems audits were performed by locating the RTI instrumented mobile Environmental Monitoring Laboratory (EML) next to a RAMS station and making simultaneous and independent measurements of the same parameters over extended time periods (minimum of six days).
2. Point-in-time audits of the gaseous air pollutant analyzers were performed utilizing calibration systems, certified by EPA prior to use, to generate accurately known reference samples for challenging the analyzers in the twelve RAMS stations audited.

Based on the performance audit results and a review of the RAMS validated hourly averages computer printouts covering the same time period as the audit, the following conclusions were drawn:

1. Except for carbon monoxide, the gaseous air pollutant measuring systems and associated calibration techniques and procedures were capable of producing data of acceptable precision and accuracy when properly maintained, i.e., calibrated (multipoint) every five weeks, preventive maintenance performed on schedule, etc.
2. Ambient CO levels less than about 2 ppm were measured low by all the RAMS stations audited indicating a systematic network bias.
3. Response times of the sulfur analyzers were much improved compared to the results from the HERL audit conducted during the week of January 19 through January 26, 1975.
4. Solar radiation data reported from Station 103 may have been inaccurate prior to and during the audit due to 60 Hz pickup on the circuits. The cause of the 60 Hz pickup was located and corrected by Rockwell shortly after the audit.
5. RAMS dew point sensors are difficult to maintain in an operational mode. In nearly all the stations audited the sensors were not

cycling but were in the cooling mode the full time that RTI was in the station. Also, the validated hourly averages reported by RAMS usually had more than one station reporting negative dew points in June.

6. Data from RAMS ambient temperature, wind speed, and wind direction measurement systems, when compared to RTI, showed good agreement.

In the third phase RTI made recommendations for the improvement of the RAMS/RAPS quality control program. These recommendations included suggestions for audit procedures, equipment requirements, data analysis and quality control organizational structure. Recommended data validation procedures included interparameter checks, range checks and lower detection limit checks. All of these recommendations can be found along with the results of the first two phases in the contract final report.

During the second contractural period (Contract No. 68-02-2407) RTI conducted three performance audits on the RAMS during 1976 and one during 1977. These audits included quantitative checks on air quality analyzers, the ambient temperature measurement systems (5 meter level), the dew point sensors and the high volume samplers located at 23 RAMS stations. The purpose of these audits was to:

1. Determine the accuracy of individual sensors at a given point in time.
2. Identify and report in a timely manner each sensor and/or system whose accuracy was found to be outside acceptable limits so that Rockwell could investigate and take immediate corrective action if required.
3. Provide estimates of measurement bias and precision for the RAMS for each parameter audited to document the quality of the RAMS measurements on a network basis.

The audit devices used to audit the gaseous air analyzers either contained NBS Standard Reference Material (SRM) or transfer standards whose traceability to NBS SRM or other acceptable primary standards were clearly established prior to the audit. Hence the auditors were able to generate known audit samples on-site. The high volume sampler flow rates were audited using a reference flow device provided by the Quality Assurance Branch of EMSL. The ambient temperature measurement systems were audited using a system similar to the RAMS system and by taking simultaneous measurements for comparison. The dew point temperature sensors were audited by performing multiple readings with an aspirated psychrometer.

Twenty-three of the 25 RAMS stations were audited during the two-week audit periods. Audits of 2 of the 23 stations were repeated after elapsed times of 5 and 10 days to allow for an estimate of the repeatability of the audit process under field conditions.

In general the conclusions drawn from the audits indicated that the RAMS network data were considered acceptable in terms of percent valid data, accuracy and precision. More detailed discussion of the results as well as the pertinent statistics can be found in the performance audit reports listed below.

Publications

Research Triangle Institute. Audit and Study of the RAMS/RAPS Programs and Recommendations for a Quality Assurance Plan for RAPS. Research Triangle Park, North Carolina. EPA Contract 68-02-1772. June 1976.

Research Triangle Institute. Independent Performance Audits on RAMS Station Sensors - Audit #1 Interim Report. Research Triangle Park, North Carolina. EPA Contract 68-02-2407. August 1976.

Research Triangle Institute. Independent Performance Audits on RAMS Station Sensors - Audit #2 Interim Report. Research Triangle Park, North Carolina. EPA Contract 68-02-2407. October 1976.

Wohlschlegel, P. S. Independent Performance Audits on RAMS Station Sensors - Audit #3 Interim Report. Research Triangle Institute, Research Triangle Park, North Carolina. EPA Contract 68-02-2407. January 1977.

Smith, F., and R. Strong. Independent Performance Audits on RAMS Station Sensors - Audit #4 Interim Report. Research Triangle Institute, Research Triangle Park, North Carolina. EPA Contract 68-02-2407. May 1977.

3.3 RAMS DATA EVALUATION STUDIES

3.3.1 MODIFICATION OF RAMS DEW POINT SENSORS

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Funding EPA Contract No. 68-02-1081, Task Order No. 57

Period of Performance May - August 1975

Summary

The purpose of this task order was to determine the feasibility of modifying the Cambridge 880 dew point sensor for accurate dew point determination during continuous operation. Continuous operation of this instrument involved cooling a mirror in the sensor cell to the dew point temperature and maintaining its surface at this temperature by means of an electro-optical feedback loop. When operated in this manner on a continuous basis, an excessive accumulation of water and other condensables was discovered with a resultant interference on the optical sensing scheme for the true dew point. This accumulated material can be cleaned from the mirror surface only by disassembling the cell and wiping the mirror with cleaning solution. Operating experience demonstrated that this cleaning procedure had to be carried out at least daily and under certain atmospheric conditions, such as high humidity, two to three times per day in order to maintain proper operation of the instrument. Since the normal operating schedule for the RAMS called for station visitation twice per week, the dew point sensors reported erroneous data a large percentage of the time.

Consequently, in this task order, the dew point sensors at RAMS Stations 105, 106, 112, 120 and 121 were modified to improve the reliability of the

dew point data without necessitating increased station maintenance visits.

This modification entailed reversing the current in the Peltier device used in the instrument to cool the sensing mirror to the dew point temperature. The result of this current reversal was to heat the mirror surface and drive off accumulated moisture and other condensable substances. The current reversal process was coupled to a timing device which heated the mirror for a period of 25 minutes, followed by a 5-minute period of normal operation in which the mirror was cooled to the dew point and regulated there. This scheme provided for a 5-minute period of dew point determination each half hour.

Analysis of data from the five modified instruments was carried out utilizing plots and printouts of level II minute values generated at the RAMS Computer Facility. Hand computation of the average dew point and outside temperature during the 5-minute cooling portion of the cycle was performed and the average relative humidity for each period was computed using these values.

Computation of the relative humidity in each case allowed the dew point to be normalized to the outside temperature being reported at the same time so that cross-station comparisons could be made. Although the validity of such cross-station comparisons could only be guessed at because very little was known about the expected variability of the relative humidity across the network, this inter-station comparison served as an indicator since no independent method of determining the true relative humidity was at hand.

The data from these modified hygrometers suggested improved performance; consequently, the remaining dew point instruments were recalled to the Central Facility for modification. However, it was decided to modify only ten instruments and place them in the RAMS stations that supported hi-volume samplers.

Later it was discovered that the Peltier device used to cool the instrument sensing mirror could not withstand the heating-cooling cycles as they began to break down after an estimated one month's use. The existing sensors were then maintained with spare parts until the end of RAMS operation.

Publication

Hern, D. H. Modification of RAMS Dewpoint Sensors. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 57 Final Report, EPA Contract 68-02-1081. July 1979.

3.3.2 PARTICULATE FILTER EFFECT ON RAMS ANALYZERS

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Funding EPA Contract No. 68-02-2093, Task Order No. 106

Period of Performance November 1975 - January 1977

Summary

Although the primary purpose of Task Order 106 was to provide for the performance of quality assurance audits, particularly during field expeditions, several special investigations were performed. One investigation directly related to RAMS was a study of the effects of particulate filters on measurements by RAMS gas analyzers. In this study new and used Teflon particulate filters were placed in the inlet of instruments measuring atmospheric pollutants. The filters were 47 mm in diameter with an average pore size of 10 microns. Gases studied were NO, O_3, $NO_2 + O_3$, $SO_2 + O_3$ diluted with either dry or humidified air. NO was obtained by diluting the contents of an NO in nitrogen compressed gas cylinder. Ozone was obtained from a constant-current ozone generator. NO_2 was obtained by the gas phase titration of NO with ozone. SO_2 was obtained from an NBS permeation tube. Equipment was set up to allow rapid change from one filter to another and from dry air to wet air (Figure 3). The flow diagram shows airflow from the cylinder to the Bendix calibrator, either directly or through a water bubbler. Output from the calibrator entered a glass manifold for distribution. Manifold air was sampled by an EG&G dew point hygrometer, the output of which was monitored by a Leeds and Northrup

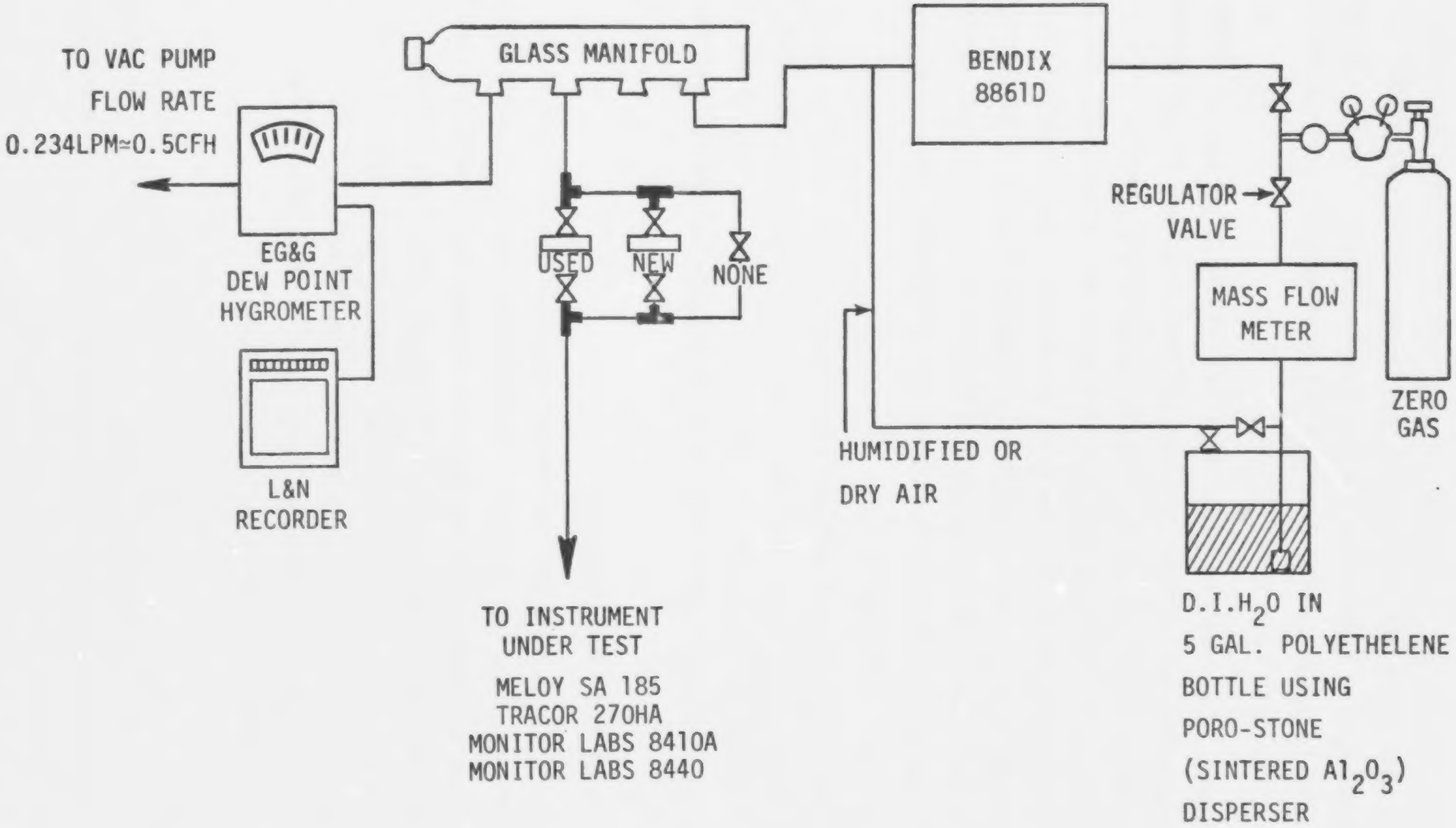

FIGURE 3. SCHEMATIC LAYOUT FOR FILTER STUDY

recorder. The dew point hygrometer was checked by deriving relative humidity from outdoor dew point and temperature measurements and comparison to relative humidity measurements taken with a sling psychrometer. Crosschecks made with relative humidity measurements from the National Weather Service indicated that differences were less than 5%.

The second line from the glass manifold led to a series of valves and filters so that the gas stream could be shifted from one filter to another (or none) without interruption or without opening the circuit. The filters were replaced during the changeover from wet to dry diluent air and again during the changeover from pollutant to pollutant. The "used" filters were taken from RAMS Station 120. Filter 'age' varied from five to thirteen days. All filters taken were obviously used as particulate matter was visible. The order of tests was randomized to remove any systematic bias. Two replicates were required per test condition.

Every test involving a different pollutant and/or humidity condition was preceeded by a run using zero gas. When the test was completed, the zero gas run was repeated. Measurements were based on an average of at least 12 readings made 4 minutes apart after the system was judged to have reached equilibrium.

Results of the study indicate:

1. Moist air alters the instrument response to NO, O_3 and SO_2. This effect can be alleviated by calibrating the instruments with air of about the same relative humidity as that which will be sampled.
2. Particulate filters, especially fresh ones, have a pronounced attenuating effect on the ozone level. This effect decreases as the filter becomes conditioned, but remains significant (5-10%).
3. None of the analyzers employed in this testing were sensitive to zero air humidity, with or without a filter.

Publication

Klein, D. C., and F. E. Littman. Quality Assurance Audits. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 106 Final Report, EPA Contract 68-02-2093. January 1978.

3.3.3 CO_2 EFFECT ON RAMS SULFUR MONITORS

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Funding EPA Contract No. 68-02-2093, Task Order No. 121

Period of Performance April - June 1977

Technical Approach

Data acquired by Rockwell International Air Monitoring Center, Research Triangle Institute and others have indicated that carbon dioxide can be an interferent in the determination of gaseous sulfur compounds by the flame photometric technique, by suppressing instrument response. Response differences of up to 20% have been reported for sample carbon dioxide concentration differences of 0 to 360 ppm. The purpose of this task order was to verify and quantify the effect of sample carbon dioxide content on the response of two types of flame photometric sulfur gas analyzers; the Tracor model 270 HA sulfur gas chromatograph and Meloy model SA 185 total sulfur analyzer.

The RAMS station gas analyzer calibration system utilized zero air which was generated by a heatless air drier and purification device. Preliminary analysis for the CO_2 content of the zero air effluent from this station zero air generation system performed by Research Triangle Institute (RTI) indicated that the percentage of ambient level CO_2 (nominally 350 to 370 ppm) which was removed by different systems within the RAMS network varied from 30 to 100 percent. The station zero air generation system influent and effluent were analyzed daily by a wet chemical technique at three RAMS stations (106, 107 and 111) for a twenty day period to determine scrubbing efficiency and to attempt to elucidate the factors, such as temperature and atmospheric moisture content, which might affect this scrubbing efficiency.

Because of the possible effect of the ambient CO_2 concentration variability on the reported sulfur gas concentration and the zero air CO_2 content, ambient air samples were taken every four hours for four individual diurnal cycles at RAMS site 106 and analyzed for CO_2 content.

The comparability of sulfur gas data reported by the two types of analyzers used in RAMS was investigated by the simultaneous operation of each at three RAMS stations over a twenty day period. The data from each of the two types of instruments were collected via the computerized data acquisition system normally installed in each RAMS station.

Periods of Data Collection

The influent/effluent and simultaneous instrument CO_2 data were collected from May 4 through May 24, inclusive at RAMS Sites 106, 107 and 111. Diurnal CO_2 data were gathered during four, twenty-four periods (May 20-21, May 24-25, May 31 - June 1, June 7-8, 1977) at RAMS Site 106.

Parameters Measured	Instrument/Method Used
Sample manifold influent/effluent carbon dioxide concentration	Homemade bubbler with flow rate measured with a Tylan mass flow meter. The influent sample was obtained using a calcium sulfate drying cartridge while the effluent sample was obtained after it passed through the RAMS scrubbing system. Samples (barium hydroxide solution) were analyzed by titration with oxalic acid solution.
Relative humidity of zero air influent	Sling psychrometer with two ventilated mercury thermometers indicating dry and wet bulb temperatures in degrees Celsius and calculated with psychometric calculator.

Parameters Measured	Instrument/Method Used (continued)
Instrument response (SO_2) with varying amounts of CO_2	Span gas with varying amounts of CO_2 were injected into the Tracor and Meloy analyzers. The SO_2 and CO_2 span gases were prepared using a NBS permeation tube, CO_2 cylinders and a portable dynamic (Bendix) dilution system.

The Meloy Model SA185 total sulfur analyzer and Tracor Model 270HA sulfur gas chromatographs used during this experiment as well as the RAMS zero air calibration system are described in Section 3.1. Ambient temperature was obtained from the RAMS ambient air temperature sensor which is also described in Section 3.1.

Calibration and Quality Control Procedures

The Bendix dynamic calibrator used in diluting the various SO_2/CO_2 span gases was calibrated prior to the experiment and afterwards using the positive soap film displacement technique. The permeation tube used was an NBS permeation tube maintained at a constant temperature and calibrated at 0.267 µl/min. The mass flow meter was calibrated at the beginning of the experiment and rechecked every week thereafter.

The barium hydroxide titration method was checked by repetitive tests.

The sulfur analyzers and other RAMS instrumentation used were subject to the same quality control and calibration techniques that are described in Section 3.1.

Location and Type of Data Available

Data are presented in the final report which can be obtained from the Task Coordinator.

Publication

Hern, D. H. Carbon Dioxide Effect on RAMS Sulfur Monitors. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 121 Final Report, EPA Contract 68-02-2093. July 1979.

3.3.4 EVALUATION OF RAMS CO DATA

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Funding EPA Contract No. 68-02-2093, Task Order No. 125

Period of Performance June - August 1977

Summary

Multipoint calibrations and quality assurance audits of the Regional Air Monitoring System indicated the presence of an unexpectedly large positive concentration intercept on the calibration curve for measurement of CO as determined by the Beckman Model 6800 air quality gas chromatographic analyzers. This intercept or "cutoff" gave rise to an elevated lower detectable limit and some error in the slope of the calibration curve as determined by the daily zero/span calibrations. The purpose of this task order was to investigate this cutoff, determine its scope and magnitude, and estimate the error in past RAMS CO analyses. The investigation was to include all stations in the RAMS network over the entire period of RAMS operations.

Two sources of information were utilized to reveal the nature of this cutoff: 1) the Beckman 6800 corrective maintenance records and 2) the multipoint calibration/quality assurance audit data. It was determined that one apparent cause of this cutoff phenomenon was that low concentrations of CO were consumed by the overconditioned stripper columns. Only CO concentrations greater than the amount consumed by the overconditioned stripper columns produced

an analytical response. Subsequently the phenomenon was referred to as the carbon monoxide breakthrough concentrations. The average network breakthrough concentration was 0.3186 ppm during the period of January 1975 through March 1977.

It was ascertained that the calibration line based on the daily zero/span calibrations causes an understatement of the CO concentration for ambient concentrations below the span point (nominally 8 ppm) and an overstatement of the CO concentration for ambient concentrations above the daily span point. As most of the RAMS ambient concentrations fall below the 8 ppm daily span point, understatement of the CO is the predominant error, but in no case does that error exceed the CO breakthrough concentration. The magnitude of the error (or understatement) of CO in the RAPS Data Bank due to this breakthrough problem decreases as the ambient concentration approaches the span point. No definitive relationship between CO breakthrough concentrations and stripper column service time or regenerative history could be determined.

Publication

Ponstingl, M. J. Evaluation of RAMS CO Data. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order 125 Final Report, EPA Contract 68-02-2093. July 1979.

4.0 UPPER AIR SOUNDING NETWORK (UASN)

Introduction

The RAMS network provided a relatively dense data base of surface winds, temperature and relative humidity. However, to achieve a truly 3-dimensional representation of the state of the atmosphere, it was necessary to supplement these measurements by monitoring the meteorological parameters aloft using balloons and airborne instrument packages. It was the objective of the Upper Air Sounding Network (UASN) to provide this needed upper air meteorological information. The combination of RAMS and UASN data would allow the determination of changes in winds and stability throughout the area, particularly as they related to terrain features and synoptic scale meteorology.

The Upper Air Sounding Network, during its existence from July 1974 through May 1977, consisted of both a temporary (Task Order No. 46) and a permanent network (Task Order No. 31 and Exhibit B of Contract 68-02-2093). The temporary network was composed of Sites 201 and 202, located in west St. Louis County and downtown St. Louis respectively (Figure 4). Sites 201 and 202 were abandoned in August 1974 as the Task Order No. 46 was only an interim operation for the Summer 1974 intensive study period. During November 1974, the four station permanent network was established under Task Order No. 31, Contract 68-02-1081 and renewed in August 1975 as part of Contract 68-02-2093. These four sites, designated 141, 142, 143 and 144, were located in downtown St. Louis; Times Beach, Missouri; south of Bellevile, Illinois; and east of Alton, Illinois respectively (Figure 4).

The following is a description of the UASN's equipment, procedures, calibrations, quality control methods and periods of operation.

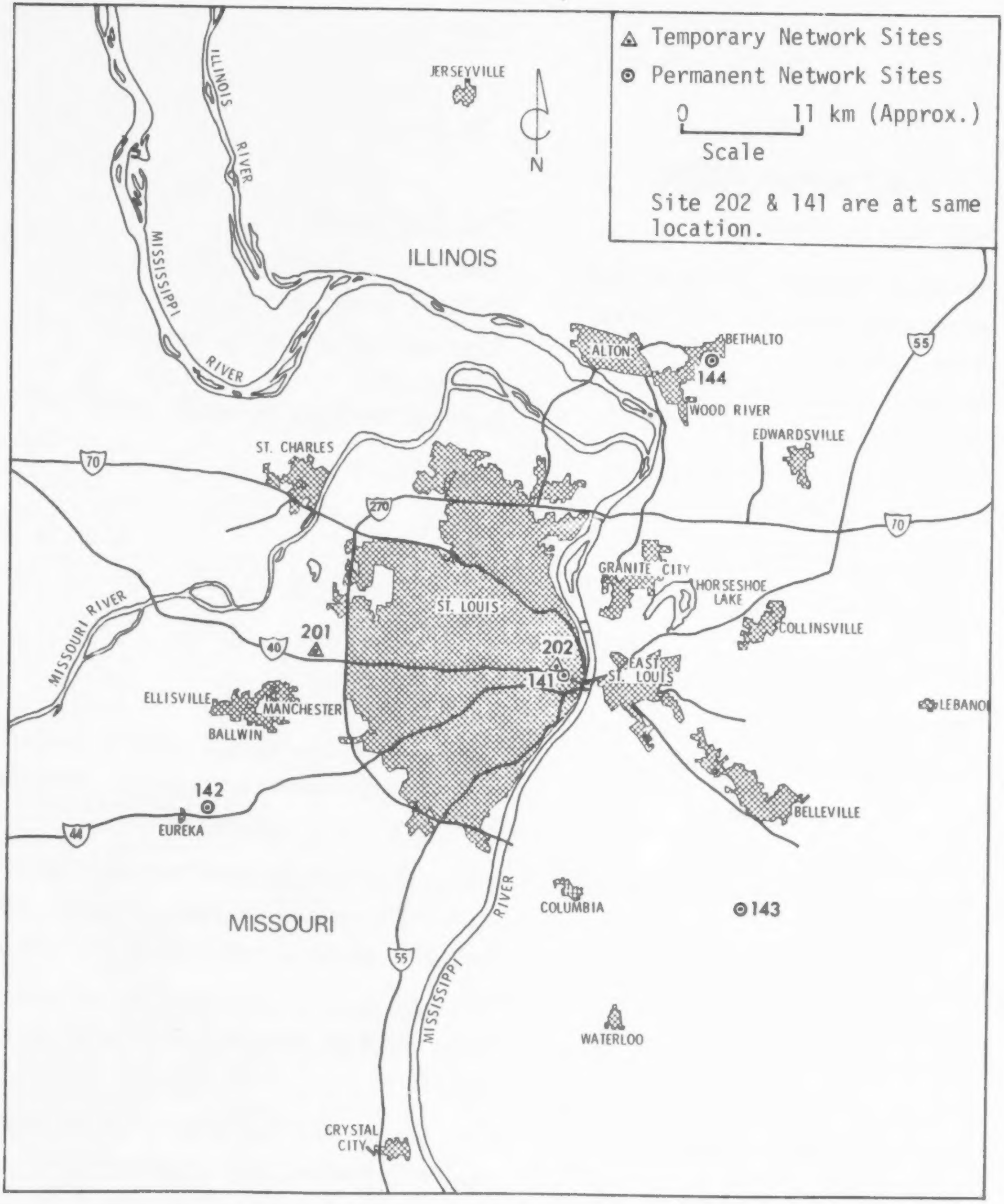

FIGURE 4. LOCATIONS OF UPPER AIR SOUNDING NETWORK SITES

4.1 UASN TEMPORARY NETWORK

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Funding EPA Contract No. 68-02-1081, Task Order No. 46

Period of Performance July - August 1974

Parameters Measured	Instrument/Method Used
Surface Barometric Pressure	One Wallace and Tiernan aneroid barometer and a Bendix aneroid barometer, both indicating in inches of mercury.
Surface Ambient Air Temperature	Sling psychrometer with two ventilated mercury thermometers indicating dry and wet bulb temperatures in degrees Celsius.
Surface Dew Point and Relative Humidity	Derived using a psychrometric calculator with readings from the ventilated thermometers.
Wind Direction and Wind Speed Aloft	Release of 10 or 30 gram pilot balloon (pibal) tracked by a single Warren Knight theodolite to 1344 meters or 1890 meters respectively. Pibals released every hour between radiosonde observa-

Parameters Measured	Instrument/Method Used (continued)
Wind Direction and Wind Speed Aloft (continued)	tions, with angular readings taken every 30 seconds for a ten minute duration. Elevation and azimuth angles field reduced to wind speed and direction utilizing a National Weather Service (NWS) winds aloft plotting board and employing the one minute overlap wind reduction technique. Wind direction reported in degrees azimuth with reference to true north and wind speed in meters per second.
Temperature, Relative Humidity, Barometric Pressure, Wind Direction and Wind Speed Aloft	Viz 403 MHz Model No. 1395 radiosonde equipped with a standard thermistor, hygristor and baroswitch. The unit was tracked by a single Warren Knight theodolite with angular readings of elevation and azimuth taken every 30 seconds. Temperature, relative humidity and barometric pressure were recorded on a Beukers or a Summer and Hill receiver. Data were then transcribed to a D-31 adiabatic chart and manually reduced to temperature and dew point in degrees Celsius, barometric pressure in millibars, wind direction in degrees azimuth with respect to true north and wind speed in meters per second.

The radiosonde was carried aloft by a 100-gram balloon at a slow ascent rate, obtaining an altitude of 700 mb in approximately 20 minutes. Radiosondes were tracked to 700 mb (approximately 3.0 km) whenever possible. Altitude was calculated in meters above mean sea level. Significant levels were selected whenever the temperature deviated ± 1°C from the established lapse rate and whenever the relative humidity deviated 10% or more from the established trend.

Reduction methodologies for surface, radiosonde and pibal observations are the same as those found in Federal Meteorological Handbooks No. 1 - Surface Observations, No. 3 - Radiosonde Observations, and No. 5 - Winds Aloft Observations.

Period of Data Collection

Upper air data were collected from July 25, 1974 through August 28, 1974 at Sites 201 and 202. Radiosondes were released at 2200, 0400, 1000 and 1600 CST for a total of 4 per day. Pibals were released hourly in between radiosonde observations for a total of 20 per day.

Calibration and Quality Control Procedures

In addition to the initial equipment testing and repairing, the electronic technician performed routine preventive maintenance and emergency repairs to ensure continuous station operation.

All data forms, recorder records and adiabatic charts were returned to operation headquarters where they were checked by an experienced observer and submitted to the EPA Task Coordinator.

The data were later subjected to the quality control checks that were established for the permanent UASN network (Section 4.2). These checks necessitated the re-evaluation of the radiosonde recorder records as the criterion for significant temperature levels was more restrictive (±0.5°C). The data were then resubmitted to the EPA Task Coordinator for final computerized reduction. The 30 second end-to-end technique was used for winds evaluation in this process.

Location of Information Concerning Data Collection

Information concerning data collection may be obtained from the EPA Task Coordinator.

Location and Type of Data Available

All UASN radiosonde and pibal data have been reduced by computer and incorporated into the RAPS data bank. Data may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Jones, A. C. Meteorological Upper-Air Support "August '74". Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 46 Final Report, EPA Contract 68-02-1081. October 1974.

4.2 UASN PERMANENT NETWORK

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Funding

EPA Contract No. 68-02-1080, Modification No. 8
EPA Contract No. 68-02-1081, Task Order No. 31
EPA Contract No. 68-02-2093, Exhibit B

Period of Performance

Modification No. 8	Used for selection, acquisition, preparation, and development of sites needed for UASN operation.
Task Order No. 31	November 1974 - August 1975
Exhibit B	August 1975 - July 1978

Parameters Measured	**Instrument/Method Used**
Cloud Type	Visually determined
Surface Barometric Pressure	Three Wallace and Tiernan aneroid barometers and one Bendix aneroid barometer, both types indicating in inches of mercury. One Weather Measure B211 microbarograph recording in millibars.

Parameters Measured	Instrument/Method Used (continued)
Surface Ambient Air Temperature	Sling psychrometer with two ventilated mercury thermometers indicating dry and wet bulb temperatures in degrees Celsius.
Surface Dew Point and Relative Humidity	Derived using a psychrometric calculator with readings from the ventilated thermometers.
Total Opaque Sky Cover	Visually determined and recorded as tenths of sky coverage.
Surface Wind Speed and Direction	Stations 141 and 142: Taylor Scientific Windscope Model No. 3120, using a three cup anemometer and direction vane. Speed displayed in knots and direction with 8 point resolution referenced to true north. Stations 143 and 144: Dwyer hand-held wind meter with speed measured in miles per hour, direction obtained by estimating during the first half minute of balloon ascent.
Wind Direction and Wind Speed Aloft	Release of 10 or 30 gram pilot balloon (pibal) tracked by a single Warren-Knight theodolite to 1344 meters or 1890 meters respectively weather permitting. Pibals were released every hour between radiosonde observations, with angular readings taken every 30 seconds for a ten minute duration. Elevation and azimuth angles field reduced to wind speed and direction utilizing either a National Weather Service (NWS) winds aloft plotting board or a programmable calculator and employing the one minute overlap wind

Parameters Measured	Instrument/Method Used (continued)
Wind Direction and Wind Speed Aloft (continued)	reduction technique. Wind direction reported in degrees azimuth with reference to true north and wind speed in knots.
Temperature, Relative Humidity, Barometric Pressure, Wind Direction and Wind Speed Aloft	Two types of radiosondes were employed. The first was a VIZ 403 MHz Model No. 1395 radiosonde equipped with a standard thermistor, hygristor and baroswitch. This unit was tracked by a single Warren Knight theodolite with angular readings of elevation and azimuth taken every 30 seconds. Temperature, relative humidity and barometric pressure were recorded by a Leeds and Northrup Model No. 63-100 portable radiosonde receiver, a Leeds and Northrup Model No. 211 CP radiosonde receiver, or a Beukers Model No. 403 radiosonde receiver. (The 403 MHz radiosonde system was the primary system at Sites 143 and 144 and served as the backup system at Sites 141 and 142.) The second type was a VIZ 1680 MHz Model No. 1392 radiosonde equipped with a standard thermistor, hygristor and baroswitch. This unit was tracked with a GMD-1A Rawin Set and associated angle printer, recording elevation and azimuth angles every 30 seconds. Temperature, relative humidity and barometric pressure were recorded by Bendix Model No. TMQ-5 GMD radiosonde receivers. (The 1680 MHz radiosondes were used at Sites 141 and 142 only.) Data were then transcribed to a D-31 adiabatic chart and

Parameters Measured	Instrument/Method Used (continued)
Temperature, Relative Humidity, Barometric Pressure, Wind Direction and Wind Speed Aloft (continued)	field reduced by hand or programmable calculator to temperature and dew point in degrees Celsius, barometric pressure in millibars, wind direction in degrees azimuth with respect to true north and wind speed in knots.

The radiosonde was carried aloft by a 100-gram balloon at a slow ascent rate, obtaining an altitude of 700 mb in 20 minutes. Radiosondes were tracked to 700 mb (approximately 3.0 km) whenever possible. Altitude was calculated in meters above mean sea level. Significant levels were selected whenever the temperature deviated ± 0.5°C from the established lapse rate and whenever the relative humidity deviated 10% or more from the established trend.

Reduction methodologies for surface, radiosonde and pibal observations are the same as those found in Federal Meteorological Handbooks No. 1 - Surface Observations, No. 3 - Radiosonde Observations, and No. 5 - Winds Aloft Observations and the UASN Reference Manual for Low-Level Radiosonde and Pibal Soundings.

Periods of Data Collection

Upper air data collection periods for each station were as follows:

Site 141 - November 18, 1974 through May 31, 1977; operational 5 days per week (Monday - Friday) except during the intensive study periods of February 2 - March 7, 1975, July 13 - August 15, 1975, February 9 - March 12, 1976, July 12 - August 13, 1976, and October 25 - November 19, 1976 when 7 day per week operations existed.

Site 142 - November 18, 1974 through December 23, 1976; operational 5 days per week (Monday - Friday) except during the intensive study periods of February 2 - March 7, 1975, July 13 - August 15, 1975, February 9 - March 12, 1976, July 12 - August 13, 1976, and October 25 - November 19, 1976 when 7 day per week operations existed.

Site 143 - February 3, 1975 through February 28, 1975
July 14, 1975 through August 15, 1975
July 12, 1976 through August 13, 1976
All operations were 7 days per week.

Site 144 - February 3, 1975 through February 28, 1975
July 14, 1975 through August 15, 1975
July 12, 1976 through August 13, 1976
All operations were 7 days per week.

Radiosondes were released at six hour intervals with pibals released hourly between radiosonde observations. Surface observations were taken at the time of each radiosonde observation. During the 5 or 7 days per week operations, weekly releases totalled 19 radiosondes and 103 pibals or 28 radiosondes and 140 pibals respectively. The hours of radiosonde releases were varied, being seasonally adjusted so that the first radiosonde each day (0400, 0500, or 0600) was released during the hour preceding sunrise to measure maximum stability.

Calibration and Quality Control Procedures

During periods of operation, the electronics technician and station observers performed tests and calibrations on the equipment and instrumentation at each station as routine maintenance, all in accordance with the latest NWS and EPA specifications (Table 6). In addition, all equipment and instrumentation utilized at Sites 143 and 144 during each intensive period were tested and calibrated prior to station operations.

Aneroid Barometers	Each station's aneroid barometer and microbarograph was calibrated using the Negretti-Zambra precision aneroid barometer. Because of its unavailability, usage of the Negretti-Zambra barometer was limited to three times during the UASN program.
Mercury Thermometers	No routine calibration was performed.

Calibration and Quality Control Procedures (continued)

Anemometer and Directional Vane	The anemometer and directional vane were calibrated monthly. A Dwyer hand-held wind meter was used to check the anemometer. The directional vane was aligned by siting on a landmark of known azimuth.
403 MHz and 1680 MHz Radiosondes	Each radiosonde was calibrated prior to release. An Electronic Craftsmen Baseline Check Box Type III was used to calibrate the thermistor and relative humidity element. The baroswitch was calibrated at the factory and set with the aneroid barometer before release.
Warren Knight Theodolites	The instruments were oriented and leveled before and checked after each release.
GMD-1A Rawin Sets	The equipment was tested and calibrated on a routine basis (Table 6). A Rawin-theodolite comparison was performed four times a year and corrective action was taken if required.

All quality control procedures were in accordance with the UASN Reference Manual for Low-Level Radiosonde and Pibal Soundings and with the latest NWS and EPA specifications for low-level meteorological soundings. Table 7 outlines the quality control work plan. After quality control checks were completed, all data were coded and submitted to the EPA Project Officer for final computerized reduction. The 30 second end-to-end technique was used for winds evaluation in this process.

Shortly after the termination of the UASN permanent network, all UASN radiosonde data were subjected to a transcription verification process. Radiosonde identification, baseline calibration data, and values of time, pressure, temperature ordinate and relative humidity ordinate were checked for correct transcription from the D-31 Adiabatic Charts to the RAPS Radiosonde

TABLE 6.

ROUTINE TESTS AND/OR CALIBRATIONS OF STATION EQUIPMENT AND INSTRUMENTATION

Tests and/or Calibrations	Normal Frequency
Barometers calibration setting comparison	every 30 days
Theodolites collimated check	every 30 days
leveling check	before and after each observation
orientation check	before and after each observation
Wind Indicators speed calibration check	every 30 days
direction check	every 30 days
Rawin Sets operational check	every 7 days
power supply check	every 7 days
tracking and sensitivity check	every 7 days
level and orientation check	every 30 days
B+ adjustment	every 30 days
IF alignment	as required
local oscillator adjustment	as required
AFC Alignment	every 30 days
line and phasing adjustment	every 30 days
antenna control adjustment	every 30 days
counterbalance adjustments	as required
cleaning and lubrication	as required
Radiosonde Recorders	
linearity check	every 7 days
waveform check	every 30 days
power supply adjustment	every 30 days
alignment	as required
cleaning and lubrication	as required

Coding Sheets. Possible keypunch errors were also checked. Descriptions of all discrepancies were recorded and submitted in regular segments to the EPA Project Officer for subsequent correction.

TABLE 7. FINAL QUALITY CONTROL WORK PLAN

PIBAL DATA CHECKS

1. Check pibal form against station log book and data tapes, if necessary, to confirm 10 or 30 gram balloon usage.
2. Review elevation and azimuth angles for angular continuity.
3. Verify that all numbers are clear and legible.
4. Check values of wind direction and speed for obvious discontinuities.
5. Check all information blocks and sequential numbers.
6. Code the RAPS formatted pibal forms for computerized reduction.

RADIOSONDE DATA CHECKS

1. Pre-Flight Checks
    a. Check to insure that all forms are present.
    b. Surface pressure is read correctly from the barometer.
    c. Release contact is read correctly from the calibration chart and the detent click setting is properly computed.
    d. Baseline computations of temperature, dew point, and relative humidity are correct.
    e. Surface computations of temperature, dew point, and relative humidity are correct.
    f. 1000, 850, and 700 mb-contact values are correct.
2. Baseline Checks
    a. Check pre-baseline record and instrument tests.
    b. Low reference of each baseline cycle is 95.0 ordinates.
    c. Temperature and relative humidity baseline ordinates are assigned correctly.
    d. Temperature evaluator setting is correct and within limits.
    e. Surface temperature ordinate is computed correctly.
    f. Relative humidity evaluator is properly set.
    g. Surface relative humidity ordinate is computed correctly.

(continued)

TABLE 7. (continued)

3. Recorder Record Checks
   - a. Temperature and relative humidity are plotted correctly on the surface level.
   - b. Release contact on the recorder record agrees with the computed value from the baseline form, and corrections, if necessary, are properly applied.
   - c. All drift lines are drawn correctly.
   - d. Drift value assignment is correct at each selected level.
   - e. Recheck trending of temperature to verify all selected significant levels and add any new levels needed.
   - f. Recheck relative humidity evaluation for significant level selection.
   - g. 1000, 850, and 700 mb mandatory levels are properly placed.
   - h. Elapsed time values are correct for each level.
   - i. Assigned contact value for each level is correct and successive levels are separated by not more than four contact values.
   - j. Assigned temperature ordinate at each level is correct.
   - k. Assigned relative humidity ordinate at each level is correct.
   - l. All drift corrections are properly added.
   - m. No zero recording error is present at the end of the recorded traces.
   - n. A careful level to level comparison of the temperature and relative humidity traces on the recorder record to the plotted curves on the adiabatic charts is performed.

4. Adiabatic Chart Checks
   - a. All entries in the informational blocks are correct.
   - b. All information in Data Block A is transcribed correctly.
   - c. All conversions from contact values to mb are correct.
   - d. Conversions from contact values to mb are correct.
   - e. Values of relative humidity are derived correctly.
   - f. Dew point temperatures and depressions are computed correctly.
   - g. Each level is plotted at the correct mb value.
   - h. Each temperature value is plotted correctly.
   - i. Relative humidity values are properly plotted.

(continued)

TABLE 7 (continued)

4. Adiabatic Chart Checks (continued)
   - j. Recheck all superadiabatic lapse rates.
   - k. Recheck the graphic determination of virtual temperatures and thicknesses.
   - l. Recheck thickness entries from the required tables and recompute the pressure altitude data.
   - m. Sight pressure - altitude curve to ensure proper plotting.

5. Time-Altitude Table and Winds Checks
   - a. Check ascent rate criteria from recorder record.
   - b. Check pressure values in time-altitude table.
   - c. Check time values in time-altitude table.
   - d. Verify above sea level altitudes extracted from pressure-altitude curve.
   - e. Above ground level values are determined correctly.
   - f. All resulting half minute interval altitudes are correct.
   - g. Horizontal distance out values are determined correctly.
   - h. Wind direction and speed are correctly computed.
   - i. For rawinsondes, all elevation angles below 12° are smoothed by the 3 value running average.
   - j. For rawinsondes, elevation and azimuth angles are checked to determine those readings obtained in the limiting angle zone and marked on the wind forms if necessary.

6. Miscellaneous Checks
   - a. Any height or pressure values in doubt are checked against available meteorological charts.
   - b. The 850 and 700 mb heights for the week's data are graphed and checked for height anomalies.
   - c. All dates and times are correct according to Standard Time in the coding blocks.
   - d. Station identification is clear on each form.
   - e. All forms for the period are included, or if a regularly scheduled observation was not taken, the required documentation is attached.

(continued)

TABLE 7 (continued)

6. Miscellaneous Checks (continued)
    f. Forms for all special observations are labeled with the reason for the observation.
    g. All forms are in chronological order and are stacked in the prescribed manner.

Location of Information Concerning Data Collection

Additional information concerning data collection may be obtained from the EPA Project Officer.

Location and Type of Data Available

All UASN radiosonde and pibal data have been reduced by computer and incorporated into the RAPS data bank. Data may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Waldron, T. L. UASN Reference Manual for Low-Level Radiosonde and Pibal Soundings. Rockwell International Air Monitoring Center, Newbury Park, California. EPA Contract 68-02-1081. January 1975.

Waldron, T. L. Operation of Regional Air Pollution Study Upper Air Sounding Network at St. Louis. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 31 Final Report, EPA Contract 68-02-1081. December 1975.

Pietrowicz, J. A., and F. A. Schiermeier. Observational Evidence of Systematic Radiosonde Temperature Sensing Anomalies. Journal of Applied Meteorology, 17(10):1572-1575, 1978.

Schiermeier, F. A. Collection and Validation of Upper Air Meteorological Data for the Regional Air Pollution Study (RAPS). Proceeding of the APCA/ASQC Specialty Conference on Quality Assurance in Air Pollution Measurements, 356-363, 1979.

Strothmann, J. A. and B. D. Winkler. Operation of Regional Air Pollution Study Upper Air Sounding Network. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. EPA Contract 68-02-2093. In preparation.

4.3 MIXING DEPTH DETERMINATION

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Funding EPA Contract No. 68-02-2093, Task Order No. 128

Period of Performance September 1977 - June 1979

Summary

During the field study portion of RAPS, 5761 radiosondes were released and tracked by the Upper Air Sounding Network (UASN) to assist in defining transport and dispersion of airborne pollutants. The purpose of this Task Order was to create a mixing depth climatology composed of mixing depths and associated transport winds and ventilation factors for use by the RAPS modelers and principal investigators in their analyses of RAPS air quality measurements.

The surface-based mixing depths, mixing depths aloft, and the daily maximum urban and rural mixing depths were subjectively determined from Cal Comp plots of radiosonde temperature, potential temperature, mixing ratio, potential wet bulb temperature, wind speed, and wind direction. The maximum mixing depths were determined by applying the maximum surface temperature to the temporally closest radiosonde, and following the dry and/or moist adiabat to its intersection with the temperature trace. Mixing depths aloft were usually the result of surface radiational cooling.

The horizontal distance out (HDO) of the balloon at the top of the mixed layer, divided by the elapsed time, yielded the transport wind speed through the surface-based mixed layer. The corresponding azimuth angle at this same level was defined as the transport wind direction. Multiplying the transport wind speed by the depth of the mixed layer produced a ventilation factor in units of m^2/sec. This factor is a measure of the volume rate of horizontal transport of air within a mixed layer per unit distance parallel to the resultant vector transport wind (m^3/sec/m).

When completed, the mixing depth data will reside in the RAPS data bank. Copies of the data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Waldron, T. L., and B. D. Winkler. UASN Mixing Depth Determination. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 128 Final Report, EPA Contract 68-02-2093. In preparation.

5.0 AERIAL MONITORING SYSTEM

Introduction

Complementing the extensive surface-based aerometric data collected by RAMS and the meteorological data supplied by the UASN, the aerial monitoring system provided a data base of aerometric measurements aloft. This vertical extension of RAMS collected data relating the distribution of pollutants and meteorological variables above the surface enabling the construction of three-dimensional depictions of pollutant distributions in the urban boundary layer. In addition to providing data for model validation, data were also obtained on conditions at the lateral boundaries of the St. Louis Region.

This aerial monitoring system consisted of three Sikorsky 58 helicopters modified to permit reasonably simple installation and removal of air sampling systems. Two air sampling systems were assembled and one system was placed in each of two helicopters with the third helicopter serving as a backup. Operating during selected periods to coincide with data gathering by the various research investigators, preselected flight paths were chosen so that for any given wind direction, aerometric soundings would be made over six to eight RAMS stations in a roughly elliptical flight pattern. The paths were often designed to provide data upwind of the urban area as well as downwind of the principal source aggregations. Soundings consisted of spirals from above the existing stable layer downward to about 60 meters above the surface. Additional flights were frequently performed to augment the data being collected during the expeditionary periods by other airborne and surface-based monitoring systems.

The following is a summary of the helicopter operations including the parameters that were measured, equipment used, calibration techniques and quality assurance activities.

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Funding

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Program Element 1AA603

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Parameters Measured	Instrument/Method Used
Carbon Monoxide	Beckman/Andros Model 7000 non-dispersive infrared analyzer. Sensitivity 0.1 ppm
Nitrogen Oxides	During 1974 dual Thermo Electron Corporation (TECO) 14B NO/NO_2 chemiluminescent analyzers were used. In all other field exercises a Monitor Labs ML8440 chemiluminescent analyzer was used. Sensitivities of the TECO 14B and ML8440 are 0.5 ppb and 1 ppb respectively.
Ozone	REM Model 612 chemiluminescent ozone analyzer. Sensitivity 0.001 ppm.

Parameters Measured	Instrument/Method Used (continued)
Sulfur Dioxide	Meloy Model SA-160 flame photometric detector. Sensitivity 0.005 ppm.
Total Hydrocarbons and Methane (non-methane hydrocarbons by subtraction)	Mine Safety Applicances Company (MSA) Model 11-2 flame ionization detector. Sensitivity 0.1 ppm for CH_4.
Light-scattering Coefficient	Meteorology Research, Inc. (MRI) Model 1550 nephelometer equipped with a preheater. Sensitivity range of 10^{-5} to 10^{-2} reciprocal meters.
Particle-size distribution	Royco Model 220 aerosol-particle monitor. This monitor was coupled with a multichannel analyzer which scaled particle counts in eight size ranges larger than 0.5 μm in diameter.
Temperature and Dew Point	EG&G Vapormate II using a model CS137 thermometer-hygrometer probe.
Pressure/Altitude	Computer Instruments Corporation (CIC) Model 8000 electric altimeter.
Total Suspended Particulates	A filter holder accommodating 37-mm diameter filter with a tapered, machined probe tip. Flow rates available through this system were 28 or 65 liters/min. The airmover was a Gelman carbon vane pump and flow was determined by measuring pressure drop across the filter with a Magnehelic gauge.

Additionally the helicopters were equipped to collect 56-liter bag samples at flow rates of 7, 14 or 28 liters per minute. A prefilter cartridge of marble chips coated with manganese dioxide powder was used to destroy O_3 thereby protecting the hydrocarbons in the sample from oxidation.

Bags were kept out of direct sunlight during transport and storage. Bags were supplied and analyzed by the various principal investigators.

Certain avionics equipment were also incorporated into the helicopter air monitoring system to provide data which were used to calculate the helicopter's position and wind fields. This equipment consisted of two Collins DME-40 (distance measuring equipment) transceivers and one Bendix RVA-33A VOR receiver. Compass headings and indicated airspeed were also recorded. A Data Device Corporation (DDC) Model 4700 synchro-to-digital converter digitized the three synchro voltages from the ship's compass and outputed the real time heading in degrees. Airspeed was measured with a CIC Model 7100 differential pressure transducer.

Data acquisition was accomplished with a ML Model 7200 R-D2 with digital clock modules C1-C4 and interfaced to a Cipher Model 70 digital tape recorder. A MFE Corporation Model M24CRAHA strip chart recorder served as backup.

Calibration and Quality Control Procedures

Calibrations

Calibrations were performed with a Bendix Dynamic Calibration System (BDCS) operated in conjunction with a Bendix heatless air dryer and a MSA catalytic oxidizer. An Aadco pure air generator was used in place of the dryer and catalytic oxidizer during the last four missions.

All flows were calibrated on the BDCS on at least a weekly basis, but when problems occurred with the BDCS more frequent flow calibrations were made.

During the first three field expeditions (Summer 1974, Fall 1974, and Winter 1975), the flowmeters used were certified only to about 5% accuracy. During the last four missions, an NBS traceable Teledyne-Hastings Miniflo Calibrator was used for flow measurements. Allowing a ±2% accuracy for flow measurement, and an additional allowance of ±2% accuracy for field standards gave a calibration input of ±4%. However, the accuracy could be as much as ±8% of the input value as the flows were measured only on a weekly basis.

Multipoint calibrations were performed biweekly. These calibrations were implemented during the first, middle and last weeks of each field expedition. Zero-air tests were performed on the same schedule. Internal zeroes of the SO_2 and CO analyzers were compared to the Aadco pure air generator or the Bendix heatless air dryer and MSA catalytic oxidizer. Comparisons also were made between the in-flight zero-grade air (Linde or Matheson zero-grade air) and the Aadco pure air generator or the Bendix heatless air dryer and MSA catalytic oxidizer. These tests produced very favorable results for O_3 and SO_2, and oxides of nitrogen. Problems occurred in the CO comparisons as the Aadco pure air generator would occasionally respond with a higher zero reading than the internal zero reading. The source of the problem was believed to be the difference in CO_2 background between each of the zero-air sources. The NO_x-NO converter efficiencies were tested weekly. When gas phase titration was used for O_3 calibrations, the converter efficiency was checked on a daily basis.

Primary calibrations of the MRI nephelometer were done in the field. The first primary calibration was performed immediately after set-up and again during the third week of operation. This absolute calibration required two data points, the scattering coefficients for pure air and for pure Freon 12®. The nephelometer was checked daily with an electronic test and zeroed and spanned per the instruction manual.

With the exception of the first two weeks of operation during the Summer 1974 Field Expedition, calibrations were performed in the following format. Immediately after a flight, the post-calibration zero was performed. Without monitor adjustment, zero air was sampled from the pure air generator and after equilibrium was achieved, the zero value from the monitor was recorded. Necessary adjustments to the zero value were then made on the air quality monitor. Following the zero adjustment, a known concentration of pollutant was generated by diluting a highly concentrated cylinder or permeation tube output with the BDCS and sampled by the monitor. After equilibrium of the signal the post-calibration span reading was recorded. The air quality sensor was then adjusted to the signal level corresponding to the known input and this value recorded. The entire calibration sequence is based on the fact that a zero value adjustment of 0.1 ppm to the air quality sensor will directly affect the span value by the same 0.1 ppm. Adjustment of a span value will not influence the zero value previously established. This method determined the exact amount of zero and span drift at that time and was applied to all SO_2, O_3, oxides of nitrogen and CO instrumentation. The sequence was also applied to the nephelometer calibrations; however, a re-zero is necessary in this particular monitor because span adjustments do affect zero values.

Throughout the RAPS project the analysis of methane and non-methane hydrocarbons remained a difficult task. Two problems restrained the collection of hydrocarbon data. The first problem was that of accurate standards for calibration. The second and most pernicious problem was that of the MSA hydrocarbon analyzer catalyst stability. It was finally resolved that, because of frequent contamination (possibly phosphate), the catalysts within the MSA (hopcalite) were not reliable. The MSA hydrocarbon analyzer is much like a gas chromatograph and pronounced temperature fluctuations also became a problem. The catalyst problem was finally resolved by using hydrocarbon-free air from a cylinder rather than relying on the catalyst to supply hydrocarbon-free air to the flame. However, only one MSA flight day can be assumed to be without these problems, and that flight was during the Summer 1976 Field Expedition, August 4, 1976.

All Royco calibrations were performed with polystyrene latex beads manufactured by Dow Corning Corporation using a calibration system fabricated by the Las Vegas Laboratory's helicopter team. The Royco calibrations were performed each evening prior to a scheduled Royco flight.

During the first three missions when all flights were based at Scott Air Force Base, Illinois, the avionics were tested routinely with equipment loaned to the EPA by the Air Force. After deployment to Smartt Field (St. Charles County Airport), avionics test equipment had to be purchased. Until the equipment was available, all avionics testing was done by test flights encircling a nearby VOR station, and by over-flights of landmarks to test the DME's. In-flight checks of the altimeter, VOR and DME data were also made routinely by comparison to the aircraft avionics which were completely independent systems.

Calibration Standards

All measurements made by the RAPS helicopters were designed to conform to the then current Code of Federal Regulations Reference Methods and, where possible, all standards were Standard Reference Material (SRM) traceable to the National Bureau of Standards (NBS). The policy of the RAPS helicopter group was to prepare a secondary field standard and analyze it relative to an NBS primary standard. The NBS standard was kept in Las Vegas and the secondary standard was used daily in the field calibrations. This procedure was designed to prevent the accidental loss of the primary standard which could occur through leakage during routine use, and to save on costs. The standards used are described below.

Carbon Monoxide (CO)

The CO primary standard was an NBS SRM mixture of CO and nitrogen contained in an aluminum cylinder. The secondary standards were CO-ultrapure air mixtures prepared by Scott-Marin in aluminum cylinders to a nominal concentration of 15 ppm.

Oxides of Nitrogen (NO and NO_2)

The initial secondary NO standard was analyzed during the 1973 Los Angeles Reactive Pollutant Program (LARPP) project to be 81 ppm by gas phase titration (GPT) (Rehme, 1976), as referenced to the Code of Federal Regulations neutral buffered potassium iodide (NBKI) method for O_3 analysis. When the cylinder was used in St. Louis during the Summer 1974 Field Expedition, it was analyzed to be 77.5 ppm in reference to a RAMS station secondary NO standard. During the Fall 1974 mission, the cylinder was again compared to NBKI by GPT and was analyzed at 72 ppm. When an NBS-certified $NO-N_2$ mixture was received in the Spring of 1975, the cylinder was again analyzed to be 72 ppm.

The RAPS helicopter field standard was then recertified to a new value and all data obtained previous to this audit were corrected for the change in the span factor. All other NO cylinder standardizations had very stable and reproducible results.

The NO standard was also tied to the ozone standard through the GPT technique as discussed in the section on ozone. During the period in 1974 when the NBS NO cylinder was on order the GPT technique was used to check the NO cylinder values and calibrations.

Ozone (O_3)

No NBS reference materials are available for O_3 calibrations. The Code of Federal Regulations Reference Method for O_3 calibration used the oxidation of an NBKI solution to calibrate. In the Spring of 1974, the O_3 calibrations were being performed with a Dasibi 1003-AH O_3 analyzer as a secondary standard. This monitor which demonstrated long-term stability was calibrated by the Code of Federal Regulations NBKI Reference Method for O_3. This secondary reference Dasibi was also used to calibrate the NO cylinders by GPT; therefore, the O_3 and NO field standards were referenced either directly or indirectly to the Code of Federal Regulations Reference Method for O_3. This method of O_3 calibration was used until June 1975. At that time an NBS NO-in-N_2 cylinder was received which allowed all secondary NO cylinders to be cross-compared directly to the NBS NO-in-N_2 cylinder. During this same period, the accuracy of the NBKI ozone reference method came under close scrutiny and testing by the EPA. The Dasibi O_3 monitor, which had been stable for nearly a year, also had developed electronic problems.

All of the developments required that an O_3 calibration be performed by GPT referenced indirectly to an NBS cylinder of NO-in-N_2 as the primary reference material. The O_3 calibration was performed daily by a GPT on the NO-NO_X analyzer using the secondary standard of NO-in-N_2.

These reference methods for O_3 and NO were used throughout the remainder of the RAPS intensive studies. Whenever the Dasibi O_3 analyzer was repaired and found to be functioning properly, a GPT would be performed directly with an NBS NO-in-N_2 cylinder. Once calibrated, the Dasibi would be taken to the field as the secondary reference for O_3 calibration. When the Dasibi was used as the secondary reference for O_3, it would be compared periodically to a GPT on the NO-NO_X monitor using the secondary standard of NO-in-N_2.

Sulfur Dioxide (SO_2)

The SO_2 calibrations were performed with NBS-certified permeation tubes. The permeation tubes were maintained at a constant temperature which was measured with a certified thermometer. At the approach to the end of the warranted lifetime of the permeation tube, the tube was compared to a newly purchased NBS permeation tube prior to replacement to ensure equivalence between them.

Methane (CH_4) and Total Hydrocarbons (THC)

Methane and non-methane standards at the low ppm concentrations were a problem for this study. At the start of the program, the NBS methane standards were out of stock, and commercially prepared standards were used, which tended to be unstable. This problem was solved with the use of Scott-Marin cylinders of methane in air which proved to be stable. Although an NBS standard was not available directly, checks were made via independent audits.

Independent Audits

Beginning with the Summer 1975 Field Expedition, audits were performed on a regular basis by the EPA/RAPS calibration van. These audits were performed after the last flight of the scheduled audit day in two different modes. In the first mode, the audit would be performed as soon as possible after the last flight and before the normal post-calibration procedures. In the second mode, the audit would be performed as soon as possible after the normal post-calibration procedure and pre-calibration for the following day's flight.

As a result of these audits, two problems were identified and corrected in the helicopter calibration process. One problem originated with the flow system providing ambient air to the NO-NO_X analyzer through the BDCS. During the first three missions, the dilution air was split by a sample "tee" with a portion of the flow exhausting to the atmosphere through a short length of tubing. When the BDCS was used outside the hangar, the wind blowing across the exhaust tube created a variable back pressure resulting in unstable flow conditions. The problem was corrected by using a longer length of tubing and shielding the exhaust point from air currents. The second problem, discovered early during the Summer 1976 mission, was caused by flow pressure gauges failing on the BDCS.

Complete audit results and additional details are contained in the final report. Information regarding the audit equipment and procedures can be found in Section 8.3.

Instrumental Corrections

The majority of air quality instrumentation used aboard the helicopters was not designed to operate within the temperature and pressure extremes encountered in an unpressurized aircraft. Consequently, a number of operational tests were made on the instruments both in the laboratory and in the field to quantify the error in the instrument output as a function of temperature and pressure. Equations were then derived to correct the data for these errors.

Basically, two approaches were taken to isolate and identify environmentally caused effects to the signal output of the instrument. Experiments were designed to test in situ instrument response under actual conditions of changing environmental factors and laboratory equipment was also used to simulate flight conditions.

Instrumental drift corrections were determined by environmental chamber testing. Instruments were placed in an environmental chamber and cycled through a temperature range of 0° to 40°C and a pressure range equivalent to a change in altitude of 600 to 3000 m MSL. Instrumental drift, defined as the difference between the signal change in the environmental chamber and the signal change expected due to the change in atmospheric density was then determined.

The instrument zero-drift was examined in flight by allowing the monitors to sample pure air from zero-grade air bottles or their internal scrubbers. With the exception of the CO monitor, the zero drifts during an aircraft spiral were negligible. During a typical flight lasting about three hours, the zero drifts of all the instruments except the CO monitor were less than 5% of full scale. To compensate for this drift, zero levels were recorded periodically during the flight and a linear interpolation of zero drift was made to correct these data.

Notably the CO monitor was extremely temperature sensitive and it was not unusual for the zero drift of the instrument to be 30% to 100% of full scale during a spiral. Corrections applied to this instrument were large therefore the CO data should be used with reservation.

The CIC pressure altimeter, Cambridge ambient temperature and dew point sensor, and MRI integrating nephelometer were not tested for environmental response as they were designed for aircraft use.

Response times of the instruments were measured both in flight and in the laboratory. A span gas was injected into each instrument through a solenoid valve mounted on the sample inlet tube. Simultaneously a strip chart recorder was started. The length of the chart before the signal began to rise from the background level was a measure of the lag time.

Linear response time corrections could not be applied to the Meloy SA160 SO_2 flame photometric analyzer as the detection technique involves a chemical combination of sulfur atoms which is a second order process.

Periods of Data Collection

Routine helicopter flights were made during the following performance periods:

Mission	Periods of Measurement
1. Summer 1974	August 7, 1974 - August 30, 1974
2. Fall 1974	November 11, 1974 - December 6, 1974
3. Winter 1975	February 3, 1975 - March 5, 1975
4. Summer 1975	July 14, 1975 - August 15, 1975
5. Winter 1976	February 14, 1976 - March 12, 1976
6. Summer 1976	July 12, 1976 - August 13, 1976
7. Fall 1976	October 26, 1976 - November 18, 1976

The exact dates and times of the flights varied because of unsuitable weather conditions and the necessity of operating under visual flight rules (VFR).

In addition to the routine flights, many other flights were flown for principal investigators conducting special experiments. Brief descriptions of these experiments with dates and times are shown in Table 8.

During the majority of flights data were recorded at five second intervals. However, during some special experiments, data were recorded at intervals as small as one second. Bag/can and filter samples were taken at a frequency and rate prescribed by the principal investigator performing the experiment.

Location of Information Concerning Data Collection

Additional information concerning data collection may be obtained from:

Francis Pooler, Jr. (MD-84)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-2649

Location and Type of Data Available

Data are available as unaveraged, engineering units on magnetic tape from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Data from the special experiments, specifically the analysis of the gas bag/can samples, particulate filters and radiometer data can be obtained from the respective investigators, as listed in Table 8.

Publication

Mage, D.T., R.B. Evans, C. Fitzsimmons, N. Hester, F. Johnson, S. Pierett, G. Sipple, and R. Snelling. The RAPS Helicopter Air Pollution Measurement Program, St. Louis, Missouri, 1974-1976. U. S. Environmental Protection Agency, Las Vegas, Nevada. In preparation.

TABLE 8. DESCRIPTION OF SPECIAL EXPERIMENTS FOR RAPS PRINCIPAL INVESTIGATORS

Calendar And Julian Date	
8/15/74 4227	A flight was made in a square pattern at constant altitude around the Wood River, Illinois, refinery complex to assess the emissions; particular emphasis was placed on examining the hydrocarbon concentrations. Principal Investigator - S. Kopczynski, EPA
8/16/74 4228	Flights were made in square patterns at constant altitude around four point sources in the St. Louis Metropolitan Area. The point sources were the Chrysler assembly plant, General Motors assembly plant, American Can Company and Monsanto Chemicals (E. St. Louis). Principal Investigator - S. Kopszynski, EPA
8/20/74 4232	Cross patterns were flown over RAMS Site 103 in coordination with ground monitoring units to determine the 3-dimensional distribution of ozone around the monitoring site. Principal Investigator - L. Chaney, University of Michigan
12/4/74 4338	Vertical profiles and horizontal cross sections were made of the Baldwin, Illinois power plant plume at intervals downwind of the stacks to characterize the emissions. Principal Investigator - R. Husar, Washington University
2/19/75 5050	Vertical profiles and horizontal cross sections were made of the Baldwin, Illinois power plant plume at intervals downwind of the stacks to characterize the emissions. Principal Investigator - R. Husar, Washington University

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
2/27/75 5058	Same as February 19, 1975, plume study (morning).
2/27/75 5058	Same as February 19, 1975, plume study (afternoon).
3/1/75 5060	Same as February 19, 1975, plume study (morning).
3/1/75 5060	Same as February 19, 1975, plume study (afternoon).
3/3/75 5062	Same as December 4, 1974, plume study.
7/15/75 5196	Cross sections and vertical profiles were made of the St. Louis urban plume to determine the position of maximum O_3 concentrations and to characterize the pollutant transport downwind of the city. Principal Investigator - E. Martinez, EPA
7/18/75 5199	Cross sections and vertical profiles were made of the St. Louis urban plume to determine the position of maximum NO concentrations and to characterize the pollutant transport downwind of the city. Principal Investigator - E. Martinez, EPA
7/18/75 5199	Same as July 15, 1975, O_3 study of the urban plume.
7/23/75 5204	Bag samples of air were taken at various altitudes over RAMS Sites 103 and 108 for hydrocarbon analysis. Principal Investigator - S. Kopczynski, EPA

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
7/24/75 5205	Bag samples of air were taken at various altitudes over RAMS Site 108 for hydrocarbon analysis. Principal Investigator - S. Kopczynski, EPA
7/24/75 5205	Flight patterns were flown along highways, near power plants, and over "clean" rural areas to collect particulate filter samples for analysis by electron microscopy. Principal Investigator - R. Draftz, Illinois Institute of Technology.
7/25/75 5206	Same as July 15, 1975, O_3 study of the urban plume.
7/30/75 5211	An experiment was run to examine sulfur transformations in the St. Louis area. Particulate filters and glass canisters packed with an absorbant were used for the study. Air was drawn through the filters and the canisters at locations upwind of the city, in the city center, and downwind of the city. Principal Investigator - W. Wilson, EPA
8/3/75 5215	Same as July 15, 1975, O_3 study of the urban plume.
8/4/75 5216	Same as February 19, 1975, plume study (morning).
8/4/75 5216	Same as February 19, 1975, plume study (afternoon).
8/4/75 5216	Repetitive spirals from 4500 feet MSL down to 600 feet MSL at RAMS Site 103 were made to determine the particulate-size distribution with the Royco 220 analyzer. The Royco malfunctioned, but other pollutant data are available. Principal Investigator - J. Peterson, EPA

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
8/4/75 5216	Metal cans were pumped full of air for subsequent laboratory analysis for fluorocarbons. One sample was taken upwind of the city and five samples were taken across the urban plume downwind of the city. Principal Investigator - J. Durham, EPA
8/5/75 5217	Same as February 19, 1975, plume study (morning).
8/5/75 5217	Same as February 19, 1975, plume study (afternoon).
8/5/75 5217	Same as August 4, 1975, study of fluorocarbon distribution.
8/5/75 5217	Same as July 30, 1975, study of sulfur transformations.
8/6/75 5218	Same as July 15, 1975, O_3 study of the urban plume.
8/7/75 5219	Helicopter spirals were made over RAMS Sites 122, 114, 118, and 103 from 4,000 feet MSL to 1,000 feet MSL to determine particulate-size distribution with a Royco 220 and supporting equipment. Principal Investigator - J. Peterson, EPA
8/7/75 5219	Bag samples for hydrocarbon analysis were taken upwind and downwind of the Wood River refinery complex. Principal Investigator - S. Kopczynski, EPA
8/7/75 5219	Bag samples for CO analysis were taken at various altitudes above RAMS Site 108. Data were to be correlated with ground monitors to determine the 3-dimensional distribution of CO. Principal Investigator - L. Chaney, University of Michigan

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
8/8/75 5220	Same as July 30, 1975, study of sulfur transformations.
8/8/75 5220	Bag samples were taken to determine the changes in hydrocarbon composition across St. Louis. Samples were taken upwind, near the center, and downwind of the city. Principal Investigator - S. Kopczynski, EPA
8/8/75 5220	Multi-stage high volume samples of air were collected for subsequent chemical analysis. High volume samples were collected upwind of the city and at several locations over the downtown area. Principal Investigator - W. Wilson, EPA
8/8/75 5220	Sulfur hexafluoride was released from towers to simulate stack emissions. The helicopters collected air samples in syringes along cross sections of the extended plume path at several intervals to determine plume dispersion characteristics. Principal Investigator - F. Shair, California Institute of Technology
8/9/75 5221	Same as August 8, 1975, sulfur hexafluoride study.
8/11/75 5223	Same as August 8, 1975, sulfur hexafluoride study.
8/11/75 5223	Same as July 18, 1975, NO study of the urban plume.
8/12/75 5224	Same as August 7, 1975, study of hydrocarbon distribution.
8/12/75 5224	Same as August 8, 1975, study of hydrocarbon composition.

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
8/12/75 5224	Same as August 7, 1975, study of CO distribution.
8/13/75 5225	Orbits were made at 4,000, 3,000, 2,000, and 1,000 feet MSL over RAMS Site 118 to determine particulate-size distribution with the Royco 220 and supporting equipment. Principal Investigator - J. Peterson, EPA
8/15/75 5227	Same as August 8, 1975, sulfur hexafluoride study.
8/15/75 5227	Same as August 8, 1975, study of hydrocarbon composition.
2/22/76 6053	Vertical spirals were made over a number of RAMS ground stations and over UASN Site 142. The emphasis was on collecting temperature soundings. The vertical profiles were, to the extent possible, taken at the same time as radiosondes were launched. Principal Investigator - J. Ching, EPA
2/23/76 6054	Same as February 22, 1976, temperature profile study (morning).
2/23/76 6054	Same as February 22, 1976, temperature profile study (afternoon).
2/24/76 6055	Same as February 22, 1976, temperature profile study.
2/25/76 6056	Vertical profiles were made over RAMS Sites 118 and 103 to determine the size distribution of particulate matter with the Royco 220 and supporting equipment. Principal Investigator - J. Peterson, EPA

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
3/6/76 6066	Vertical profiles were made over Smartt Field and other selected sites to obtain temperature profiles. Principal Investigator - J. McElroy, EPA
3/7/76 6067	Same as March 6, 1976, temperature profile study.
7/16/76 6198	Same as February 25, 1976, Royco mission.
7/20/76 6202	Same as February 25, 1976, Royco mission.
7/20/76 6202	Same as July 15, 1975, O_3 study of the urban plume.
7/22/76 6204	Same as July 15, 1975, O_3 study of the urban plume.
7/23/76 6205	Cross sections and vertical profiles were made of the St. Louis urban plume in support of the DA VINCI balloon flights. Principal Investigator - B. Zak, Sandia
7/23/76 6205	Same as February 25, 1976, Royco mission.
7/23/76 6205	Same as July 15, 1975, O_3 study of the urban plume.
7/26/76 6208	Same as February 25, 1976, Royco mission.
7/27/76 6209	Same as March 6, 1976, temperature profile study.

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
7/28/76 6210	Vertical profiles were made over RAMS Sites 122 and 114 to determine the size distribution of particulate matter with the Royco 220 and support equipment. Principal Investigator - J. Peterson, EPA
7/29/76 6211	Vertical profiles were made over Sangamon, Illinois, to provide information on the temperature structure of the atmosphere. The work was done to support studies done by Argonne National Laboratories. Principal Investigator - B. Hicks, Argonne National Laboratory
7/30/76 6212	Same as March 6, 1976, temperature profile study.
7/30/76 6212	Same as February 22, 1976, temperature profile study.
7/31/76 6213	Study of plume behavior at the Portage Des Sioux power plant. Principal Investigator - R. Husar, Washington University
8/8/76 6221	Same as March 6, 1976, temperature profile study (early morning).
8/8/76 6221	Same as March 6, 1976, temperature profile study (mid-morning).
8/8/76 6221	Same as July 31, 1976, study of Portage Des Sioux plume (mid-morning).
8/10/76 6223	A downward-looking radiometer was carried by the helicopter to measure the reflected light intensity. Principal Investigator - J. Peterson, EPA
8/10/76 6223	Same as July 15, 1975, O_3 study of the urban plume.

(continued)

TABLE 8. (continued)

Calendar And Julian Date	
8/12/76 6225	Same as July 31, 1976, study of Portage Des Sioux plume.
11/8/76 6313	Horizontal cross sections and vertical profiles of the Labadie power plant plume were made to gather pollution data for correlation with simultaneous measurements of sulfur hexafluoride dispersion characteristics. Principal Investigator - F. Shair, California Institute of Technology
11/9/76 6314	Same as November 8, 1976, sulfur hexafluoride study.
11/12/76 6317	Same as November 8, 1976, sulfur hexafluoride study.

6.0 POLLUTANT TRANSPORT AND DIFFUSION STUDIES

Introduction

Since mathematical dispersion formulations are inherently limited in accuracy by definition of the boundary layer structure, including its turbulent properties as implicitly assumed, adequate description of this structure is vital for model validation studies.

The pollutant transport and dispersion studies consisted of a series of experiments directed toward understanding and subsequently describing the relationships between atmospheric, dynamic, kinematic, and energetic processes that occur in the urban boundary layer and their resultant impacts on the transport and dispersion of pollutants. Of particular interest was the effect on the boundary layer of the widely varying thermal and mechanical properties of the urban surface.

The experiments described in Section 6.0 may be segregated into two areas of emphasis, those primarily dealing with describing the effect of the urban area on the boundary layer and those associated with understanding the mechanisms that produce this urban effect. The former refers to the spatial and temporal definition of the boundary layer over the St. Louis region, whereas the latter refers to the investigations into the various components of the energy budget.

6.1 DESCRIPTION OF BOUNDARY LAYER

6.1.1 BOUNDARY LAYER STRUCTURE STUDY

6.1.1.1 FOSTAIRE INSTRUMENTED HELICOPTER

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Funding

EPA Contract No. 68-02-1081, Task Order Nos. 2, 15, 48, 60 (Rockwell)
EPA Contract No. 68-02-2000 (Environmental Quality Research)
EPA Contract No. 68-02-2093, Task Order Nos. 109, 116, 118 (Rockwell)

Periods of Performance

Task Order No. 2	July - August 1973
Task Order No. 15	February - March 1974
Task Order No. 48	July - August 1974
Contract No. 68-02-2000	February - March 1975
Task Order No. 60	July - August 1975

Task Order No. 109	February - March 1976
Task Order No. 116	July - September 1976
Task Order No. 118	October - December 1976

Technical Approach

In order to define those properties and conditions of the atmospheric boundary layer structure which contribute to the transport and diffusion of pollutants, a series of field experiments on boundary layer structure were conducted in the St. Louis Metropoliton Area as part of the RAPS program. The specific objective of these experiments was to advance the understanding and description of the relationships between atomospheric dynamic, kinematic, and energetic processes which occurred in this boundary layer with particular interest devoted to the spatial and temporal variations caused by differential thermal and mechanical properties of the urban surface.

To achieve this objective, a Fostaire instrumented Bell 47J helicopter obtained vertical profiles of temperature, moisture (dew point temperature), sulfur dioxide (SO_2) concentration and total light back scattering by aerosols (b_{scat}) via soundings (vertically ascending spirals) from near the surface through the extent of the boundary layer at selected locations across the St. Louis Metropolitan Area.

Initially, data were collected at 30 meter intervals during the helicopter spirals from as close to the surface as safety would permit, and through the extent of the boundary layer. Beginning in the summer 1975, the measurements were recorded continuously on a data logger.

Periods of Data Collection

Task Order No. 2	July 30 - August 25, 1973
Task Order No. 15	February 14 - March 6, 1974
Task Order No. 48	July 25 - August 27, 1974
Contract 68-02-2000	February 3 - March 7, 1975
Task Order No. 60	July 12 - August 15, 1975
Task Order No. 109	February 15 - March 6, 1976
Task Order No. 116	July 12 - August 14, 1976
Task Order No. 118	October 25 - November 19, 1976

Parameters Measured	Instrument/Method Used
Temperature, Pressure, Sulfur Dioxide (SO_2) Concentration	A Sign-X Analyzer System consisting of SO_2 analyzer and scrubber, and temperature and pressure-altitude sensors.
Moisture (Dew Point Temperature)	EG&G Vapor Mate II dew point temperature system. Optically sensed, thermoelectrically cooled dew point hygrometer. Instrument range of -40°C to +50°C with a 0.25°C nominal resolution.
Light Scattering Coefficient	MRI Model No. 1561 Integrating Nephelometer measuring light back scattering coefficient (b_{scat}). The range of operation of the nephelometer is 0.1 to 10.0 x $10^{-4}M^{-1}$. Accuracy is ±10% of scale.

Data acquisition was accomplished with a Hewlett-Packard dual-pen electrostatic strip chart recorder interfaced to a EC-22 control unit for a Metrodata data logger.

Calibration and Quality Control Procedures

Sign-X Analyzer System

SO_2 Analyzer and Scrubber	Zero and span check prior to each flight.
Temperature Sensor	Zero and span check before each experiment using a standard decade box.

The EPA SO_2 portable calibrator was compared with the EPA Winnebago Tracor System to assure integrity of the system before auditing the helicopter system. Following obtainment of satisfactory comparative readings, a four point calibration audit was performed on the Sign-X SO_2 analyzer with close agreement to the previously established calibration curves.

EG&G Vapor Mate II Dew Point Temperature System	Zeroed and checked before each flight.
MRI Integrating Nephelometer	Calibration was accomplished by introducing first clean air, then Freon-12

into the sample chamber. The Rayleigh scattering of these two gases is used to adjust the instrument to preset values.

In addition, all equipment was calibrated at Research Triangle Park prior to and following each experiment.

Location and Type of Data Available

Reports concerning data collection may be obtained from the EPA Task Coordinators. Data are available on magnetic tape as part of the RAPS data bank and may be obtained by contacting:

RAPS Data Manager
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Clarke, J. F., and J. L. McElroy. Effects of Ambient Meteorology and Urban Morphological Features on the Vertical Temperature Structure Over Cities, Presented at Annual Meeting of the Air Pollution Control Association, Denver, Colorado. June 1974.

Jones, A. C. Final Report for St. Louis Boundary Layer Study 'Summer 1973'. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 2 Final Report, EPA Contract 68-02-1081. April 1974.

Jones, A. C. Final Report for St. Louis Boundary Layer Study 'Winter 1974'. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 15 Final Report, EPA Contract 68-02-1081. March 1974.

Jones, A. C. Regional Air Pollution Study Final Report, Task Order No. 48. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 48 Final Report, EPA Contract 68-02-1081. September 1974.

McElroy, J. L., J. F. Clarke, and J. M. Godowitch. Urban Boundary Layer Structure During Sunset-Sunrise Transition Periods. Presented at the Fall Annual Meeting of the American Geophysical Union, San Francisco, California. December 1973.

Publications (continued)

McElroy, J. L., and J. F. Clarke, Atmospheric Diffusion during Sunset and Sunrise Transitional Periods. Proceedings of the Symposium on Atmospheric Diffusion and Air Pollution, Santa Barbara, California. September 1974.

McElroy, J. L. Variations in Mixing Layer Height Across Metropoliton St. Louis. Presented at the First Conference on Regional and Mesoscale Modeling, Analysis and Prediction. Las Vegas, Nevada. May 1975.

Waldron, T. L. Summer 1975 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 60 Final Report, EPA Contract 68-02-1081. January 1976.

Waldron, T. L. St. Louis Winter 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 109 Final Report, EPA Contract 68-02-2093. May 1976.

Waldron T. L. St. Louis Summer 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 116 Final Report, EPA Contract 68-02-2093. May 1977.

Waldron, T. L. St. Louis Fall 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 118 Final Report, EPA Contract 68-02-2093. March 1977.

6.1.1.2 MOBILE PIBAL SUPPORT

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Funding

EPA Contract No. 68-02-1081, Task Order Nos. 4, 18, 47
EPA Contract No. 68-02-2093, Task Order Nos. 109, 116, 118

Periods of Performance

Task Order No. 4	July - August 1973
Task Order No. 18	February - March 1974
Task Order No. 47	July - August 1974
Task Order No. 109	February - March 1976
Task Order No. 116	July - September 1976
Task Order No. 118	October - December 1976

Technical Approach

In order to develop mathematical dispersion formulations for the Regional Air Pollution Study, it was necessary to recognize and define those properties and conditions of the boundary layer structure which contribute to the transport and diffusion of pollutants. To help achieve this, a series of field experiments on atmospheric boundary layer structure was conducted in the St. Louis Metropolitan Area. As an integral part of these studies, mobile pibal observations were effected to obtain simultaneous profiles of wind speed and wind direction through the vertical extent of the boundary layer.

These observations were taken at half hour intervals at various site locations in the metropolitan area. Site locations were varied to correspond with other investigations (helicopters, van, etc.) involved in the boundary layer study.

Periods of Data Collection

Task Order No. 4	August 7-25, 1973
Task Order No. 18	February 17, 1974 - March 7, 1974
Task Order No. 47	July 29, 1974 - August 24, 1974
Task Order No. 109	February 17, 1976 - March 10, 1976
Task Order No. 116	July 14, 1976 - August 8, 1976
Task Order No. 118	October 25, 1976 - November 18, 1976

Parameters Measured	Instrument/Method Used
Wind speed and wind direction	10 or 30 gram pilot balloon (pibal) observations using the single theodolite method. Calculated wind speed and direction from angular values observed at a constant time interval of 20 seconds.

Calibration and Quality Control Procedures

All pibals were released in accordance with Upper Air Sounding Network procedures (Section 4.0). Because mobile pibal sites orientation points have to be determined, a compass with sighting apparatus was used at each site to locate a reference point for Magnetic North. A reference point for True North was then established by correction for the appropriate magnetic declination angle, obtained from U.S. Geological Survey maps.

Location and Type of Data Available

Copies of the task order final reports and additional information may be obtained from the EPA Task Coordinators. Data are available on magnetic tape as part of the RAPS data bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Jones, A. C. St. Louis Experiments (SLEPS). Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 4 Final Report, EPA Contract 68-02-1081. July 1974.

Jones, A. C. 'Winter 1974' Meteorological Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 18 Final Report, EPA Contract 68-02-1081. April 1974.

Jones, A. C. Meteorological Upper-Air Support 'August 1974'. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 47 Final Report, EPA Contract 68-02-1081. November 1974.

Waldron, T. L. St. Louis Winter 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 109 Final Report, EPA Contract 68-02-2093. May 1976.

Waldron, T. L. St. Louis Summer 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 116 Final Report, EPA Contract 68-02-2093. May 1977.

Waldron, T. L. St. Louis Fall 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 118 Final Report, EPA Contract 68-02-2093. March 1977.

6.1.1.3 MOBILE RADIOSONDE SUPPORT

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-1081, Task Order No. 18

Period of Performance February - March 1974

Technical Approach

In supplementing the St. Louis Boundary Layer Structure Study, mobile radiosonde observations were effected from a site located at the base of the St. Louis Gateway Arch to provide a vertical representation of temperature, pressure, moisture, and wind within the atmospheric boundary layer.

Period of Data Collection

Upper air data were collected from February 11, 1974 through March 6, 1974 from a site located at the base of the St. Louis Gateway Arch.

Parameters Measured	Instrument/Method Used
Temperature, Relative Humidity, Barometric Pressure, Wind Direction and Wind Speed Aloft	Viz 403MHz radiosonde equipped with a standard thermistor, hygristor and baroswitch. The unit was tracked using the single theodolite method. Temperature, relative humidity and barometric pressure were recorded, transcribed to D-31 Adiabatic Charts, and hand reduced to

Parameters Measured	Instrument/Method Used (continued)
	temperature and dewpoint in degrees Celsius, barometric pressure in millibars, wind direction in degrees azimuth with respect to true north and wind speed in meters per second. The radiosonde was carried aloft by a 100-gram balloon and tracked to 700 mb. (approximately 3.0 km) whenever possible. Final data reduction was implemented by the RAPS computer for submission to the RAPS data bank.

Calibration and Quality Control Procedures

In addition to the initial equipment calibration and testing, an EPA electronics technician performed all maintenance and repairs. All radiosonde data were quality controlled in accordance with Upper Air Sounding Network Quality Control procedures (Section 4.0).

Location and Type of Data Available

Copies of the final report and additional information may be obtained from the EPA Task Coordinator. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Jones, A. C. 'Winter 1974' Meteorological Support. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 18 Final Report, EPA Contract 68-02-1081. April 1974.

6.1.1.4 ILLINOIS STATE WATER SURVEY RADIOSONDE SUPPORT

Principal Investigator	Project Officer
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(217) 333-2210	(702) 736-2969

Funding

Funds for the Summer 1973 Boundary Layer Structure Study, Illinois State Water Survey Mobile Radiosonde Support were provided by the Department of Energy (DOE) (formerly ERDA, formerly AEC), the National Science Foundation, and the Environmental Protection Agency.

Period of Performance July - August 1973

Technical Approach

Under a cooperative program by the Illinois State Water Survey, METROMEX and the Environmental Protection Agency, RAPS, upper air soundings were taken at the Gateway Arch in St. Louis. These soundings provided supplementary data for the Summer 1973 Boundary Layer Structure Study conducted in the St. Louis Metropolitan Area.

Period of Data Collection

Upper air sounding data were collected from the St. Louis Gateway Arch during July and August 1973. The radiosonde release frequency was two per day with occasional special soundings also released.

Parameters Measured	Instrument/Method Used
Temperature, Relative Humidity, Barometric Pressure, Wind Direction and Wind Speed Aloft	Viz 403MHz radiosonde equipped with a standard thermistor, hygristor and baroswitch. The unit was tracked using the single theodolite method.

Calibration and Quality Control Procedures

Calibration and Quality Control procedures were performed by personnel of the Illinois State Water Survey.

Location and Type of Data Available

Information on the radiosonde observations may be obtained from the Principal Investigator. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

None.

6.1.1.5 EPA INSTRUMENTED VAN

Principal Investigator

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Task Coordinators

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Research Triangle Park, NC 27711

(919) 541-4524

Funding

EPA Contract No. 68-02-2000 (Environmental Quality Research)
EPA Contract No. 68-02-1081, Task Order No. 60 (Rockwell)
EPA Contract No. 68-02-2093, Task Order Nos. 109, 116, 118 (Rockwell)

Periods of Performance

Contract No. 68-02-2000	February - March 1975
Task Order No. 60	July - August 1975
Task Order No. 109	February - March 1976
Task Order No. 116	July - September 1976
Task Order No. 118	October - December 1976

Technical Approach

To distinquish those features of the boundary layer structure elusive to the helicopter at ground level, an instrumented van obtained surface measurements of temperature, dew point temperature, sulfur dioxide (SO_2) concentration, and total light scattering by aerosols (b_{scat}) at selected locations across the urban/rural complex.

Periods of Data Collection

Contract No. 68-02-2000	February 3 - March 7, 1975
Task Order No. 60	July 16 - August 15, 1975
Task Order No. 109	February 19 - March 10, 1976
Task Order No. 116	July 22 - August 12, 1976
Task Order No. 118	October 25 - November 19, 1976

Parameters Measured	Instrument/Method Used
Temperature, Sulfur dioxide (SO_2) concentration	A Sign-X Analyzer System consisting of SO_2 analyzer and scrubber, and temperature sensor.
Moisture (Dew Point Temperature)	EG&G Vapor Mate II dew point temperature system. Optically sensed, thermoelectrically cooled dew point hygrometer. Instrument range of -40°C to +50°C with 0.25°C nominal resolution.
Light Scattering Coefficients	MRI Model No. 1561 Integrating Nepholometer measuring light back scattering coefficient. The range of operation of the nephelometer was 0.1 to 10.0 x $10^{-4}M^{-1}$. Accuracy was ±10% of scale.

Measurements were usually obtained along formatted highway routes with preselected observation points. Once a route for a particular experiment was selected, observations were taken round trip along the route until completion of the experimental period. Each route used by the instrumented van was designed to coincide with a helicopter flight pattern. The van was utilized for measurements during all days of the above observation intervals, except during bad weather and equipment malfunctions.

Calibration and Quality Control Procedures

All calibration procedures were exactly the same as those of the Fostaire instrumented helicopter (Section 6.1.1.1) and were performed before each experimental period and following each loop completion of a formatted highway route.

Location and Type of Data Available

Reports concerning data collection may be obtained from the EPA Task Coordinators. Data are available on magnetic tape as part of the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Waldron, T. L. Summer 1975 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 60 Final Report, EPA Contract 68-02-1081. January 1976.

Waldron, T. L. St. Louis Winter 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 109 Final Report, EPA Contract 68-02-2093. May 1976.

Waldron, T. L. St. Louis Summer 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 116 Final Report, EPA Contract 68-02-2093. May 1977.

Waldron, T. L. St. Louis Fall 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 118 Final Report, EPA Contract 68-02-2093. March 1977.

6.1.1.6 EPA INSTRUMENTED TEMPERATURE VEHICLE

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Las Vegas, NV 89114
(702) 736-2969

Funding

Environmental Protection Agency
EPA Contract No. 68-02-1081, Task Order No. 60

Periods of Performance

EPA (in house)	August 1973 - March 1975
Task Order No. 60	July - August 1975

Technical Approach

In support of the RAPS Boundary Layer Structure Study, a series of field experiments were conducted in the St. Louis Metropolitan Area. In conjunction with these experiments, a mobile temperature sensing vehicle was used to obtain temperature and dew point temperature measurements across the surface of the urban/rural experimental area, primarily along the interstate highways. During operation, locations and times were recorded on a voice recorder with simultaneous event marks made on the dual-pen strip chart recorder, thus providing a post-experimental cross reference between times and locations along the routes and the traces on the recorder records.

Periods of Data Collection

EPA (in house)	August 1 - 25, 1973
EPA (in house)	February 16 - March 6, 1974
EPA (in house)	July 27 - August 24, 1974
EPA (in house)	February 3 - March 7, 1975
Task Order No. 60	July 16 - August 15, 1975

Parameters Measured	Instrument/Method Used
Surface Temperature	Battery operated (homemade) resistance box interfaced to a strip chart recorder.

Calibration and Quality Control Procedures

The resistance box was calibrated before and after each period of operation using a single point calibration for each range.

Location and Type of Data Available

Information concerning data collection may be obtained from the EPA Task Coordinator. The data are available on magnetic tape as part of the RAPS data bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Waldron, T. L. Summer 1975 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 60 Final Report, EPA Contract 68-02-1081. January 1976.

6.1.1.7 EPA MOBILE LIDAR VAN

Principal Investigator

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Research Triangle Park, NC 27711

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Project Officers

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Jason K. S. Ching (MD-80)
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Research Triangle Park, NC 27711

(919) 541-4524

Funding Environmental Protection Agency

Period of Performance July 1973 - March 1976

Technical Approach

The SRI Mark VIII ruby lidar was used in both stationary and mobile operations in Greater St. Louis during the RAPS intensive study periods. The specific sites and routes selected depended on the air currents operating at the time of observation. The main stationary observation locations were the Gateway Arch, the UASN Station 141, the Holiday Inn on Market Street, the Arena parking lot, Busch Stadium, and the Army Records Center in Overland. The major mobile observation routes included I-70, I-44, I-55 and US-40.

Periods of Data Collection

The exact times of data collection varied within the following periods to coincide with other experimental efforts:

July 30 - August 25, 1973
July 25 - August 27, 1974
February 3 - March 7, 1975
July 12 - August 15, 1975
February 15 - March 6, 1976

For stationary operation, lidar shots were nominally made at 20 second intervals. For mobile operation, ten pulses per minute were generated.

Parameter Measured	Instrument/Method Used
Relative Aerosol Distribution	SRI MARK VIII Q-switch ruby laser lidar recording on both a video magnetic disk recorder and on an oscilloscope equipped with a 35-mm recording camera.

Calibration and Quality Control Procedures

In addition to the initial equipment calibration and testing prior to each field experiment, an onsite EPA electronics technician performed periodic calibrations during the field operations.

Location and Type of Data Available

Video disc data for graphical display are available through the RAPS Data Bank. For information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

McElroy, J. L. Details of Urban Atmospheric Boundary Layer Structure Revealed by Ground-Based and Airborne Downlooking LIDAR Systems. Presented at the 1975 International Laser Radar Conference, Menlo Park, California. November 1975.

6.1.1.8 SRI MOBILE LIDAR VAN

Principal Investigator	Project Officer
Edward E. Uthe SRI International 333 Ravenswood Avenue Menlo Park, CA 94025 (415) 326-6200	Jason K. S. Ching Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-4524

Funding EPA Contract No. 68-02-2418

Period of Performance July 1976 - March 1978

Technical Approach

During late July and early August 1976, lidar measurements were made near UASN Site 141 in downtown St. Louis as part of the RAPS program. The mixing depth was determined visually at 10-minute intervals by subjective inspection of both the lidar backscatter data (recorded at 30-second intervals using SRI's MARK IX ruby lidar) and the radiosonde profiles of temperature, humidity, and wind. In identifying the mixing depth, one looked for boundaries between turbid and clean air as shown by differing brightness in pictorial displays of the lidar backscatter data. Vertical gradients were also computed of the digital lidar data. In simple cases, the boundary corresponding to the largest negative vertical gradient represented the mixing depth.

Period of Data Collection

Data were collected from July 26 through August 13, 1976. Lidar backscatter data were collected at 30-second intervals. Mixing depths were determined at 10-minute intervals.

Parameter Measured	Instrument Used
Relative Aerosol Distribution	SRI MARK IX lidar recording on both a video magnetic disc recorder and on an oscilloscope equipped with a 35-mm recording camera.

Calibration and Quality Control Procedures

In addition to the initial equipment calibration and testing prior to each field experiment, an onsite SRI electronics technician performed periodic calibrations during the field operations.

Location and Type of Data Available

Mixing depth data in graphical and tabular form are published in the two SRI technical notes listed under Publications. Additional information may be obtained from the EPA Project Officer.

Publications

Endlich, R. M., F. L. Ludwig, and E. E. Uthe. Mixing Depth at St. Louis During the RAPS Program Determined from Lidar and Radiosonde Data. SRI International, Menlo Park, California. Technical Note 1, EPA Contract 68-02-2418. January 1978.

Endlich, R. M., F. L. Ludwig, and E. E. Uthe. Graphs of Objectively Determined Mixing Depth and Integrated Aerosol Content at St. Louis during the RAPS Program. SRI International, Menlo Park, California. Technical Note 2, EPA Contract 68-02-2418. February 1978.

Endlich, R. M., F. L. Ludwig, and E. E. Uthe. An objective Method for Determining the Mixing Depth from Lidar Records. SRI International, Menlo Park, California. EPA Contract 68-02-2418. March 1978.

6.1.1.9 EPA/EMSL LIDAR AIRCRAFT

Principal Investigator	Project Officer
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Environmental Monitoring and Support Laboratory	Environmental Monitoring and Support Laboratory
Las Vegas, NV 89114	Las Vegas, NV 89114
(702) 736-2969	(702) 736-2969

Funding

Environmental Protection Agency
Regional Air Pollution Study

Periods of Performance

EPA/EMSL	February 1974
EPA/RAPS	August 1974 and August 1975

Technical Approach

As an aid in defining the temporal and spatial variation of the mixed layer over the St. Louis area, the EPA/EMSL lidar aircraft from Las Vegas was utilized in three field experiments of the Boundary Layer Structure Study. The purpose of the lidar aircraft was to overfly the study area while simultaneously operating a downward looking lidar. The variation of the mixed layer over a wide area could then be determined through evaluation of vertical gradients of relative aerosol distribution. Additionally, the airborne lidar was tested as a remote sensing device for plume tracking.

Three distinct scenarios were flown during the field experiments. The first consisted of perpendicular transects over the metropolitan area during studies of the urban heat island in an attempt to define the spatial variation of the mixed layer. The two remaining scenarios consisted of cross sectional traverses of the entire urban plume or of singular point source plumes.

Periods of Data Collection

February 14-28, 1974
August 5-20, 1974
August 4-14, 1975

Parameters Measured	Instrument/Method Used
Relative Aerosol Distribution	Ruby Laser lidar recording on strip chart recorder during February 1974 and August 1974. Beginning in August 1975, the output was processed through a Biomation digitizer to a Kennedy tape drive.

Calibration and Quality Control Procedures

In addition to the initial equipment calibration and testing prior to each field experiment, an onsite EPA electronics technician performed periodic calibrations during the field operations.

Location and Type of Data Available

For information concerning data collection and availability, contact the EPA Project Officer.

Publications

Melfi, S. H., J. L. McElroy, D. H. Bundy, J. A. Eckert, and J. L. Guagliardo. Boundary Layer Investigations using a Down-Looking Airborne Lidar System. Presented at the Sixth International Laser Radar Conference, Sendai, Japan. September 1974.

Eckert, J. A., J. L. McElroy, D. H. Bundy, J. L. Guagliardo, and S. H. Melfi. Downlooking Airborne Lidar Studies - August 1974. Proceedings of the International Conference on Environmental Sensing and Assessment, Las Vegas, Nevada. September 1975.

Eckert, J. A., J. L. McElroy, D. H. Bundy, J. L. Guagliardo, and S. H. Melfi. Airborne Lidar RAPS Studies, February 1974. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada. June 1976. EPA-600/4-76-028.

6.1.1.10 NOAA OPTICAL LASER ANEMOMETER

Principal Investigator	Project Officers
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	Jason K. S. Ching (MD-80) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-4524

Funding EPA Interagency Agreement No. IAG-D7-0305

Period of Performance November - December 1976

Technical Approach

Line-averaged transverse winds blowing through laser beams were recorded using laser anemometers. The laser beams were arranged to shoot around the perimeter of a polygon. In the experiment, three separate polygons were utilized. The first study area was a square roughly 300 meters on a side located in a rural setting in the flat Mississippi bottom lands east of St. Louis near RAMS Site 109. The second study site was a large rectangle located in the same area--2.8 km on its longest side. The third area, located in urban St. Louis (UASN Site 141), was a large right triangle having sides of 1.5 km. The data collected during the study can be used to calculate the convergence of the horizontal wind at the measured heights within the planetary boundary layer.

Period of Data Collection

Typically, before and after each data gathering period, grounding files were created to determine the line and system noise for each velocity voltage channel. The observation intervals for grounding files were mostly between 5 to 10 min. and those for data files between 1/2 to 2 hours. The actual period of data collection was November 3 through December 4, 1976.

Parameters Measured	Instrument/Method Used
Line-averaged transverse wind velocities	Laser anemometer - transmitter by C. W. Radiation, Inc. (Model No. LSR-4); receiver by Campbell Scientific

Calibration and Quality Control Procedures

The absolute calibration of each of the sensors against a reference line of cup anemometers arranged along the beam has been done by the manufacturer (Campbell Scientific Co.). A comparison of the response of each laser receiver was made by positioning each of the four transmitter-receiver pairs side by side with closely spaced parallel beams. Twelve hours of data were collected in this configuration on the flat Snake River Plain in Idaho prior to the study and was used as a reference for scaling the study data. The accuracy of the telemetry system in transferring the signal from the remote receivers to the digital system was established for each configuration used in the experiment. For comparison purposes in the field, a Climet wind system was operated at each site.

Location and Type of Data Available

All data were recorded on 9-track magnetic tapes of density 1600 bpi compatible with the IBM 360/75 computer. These data will be available through the RAPS Data Bank. For more information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Ricks, N. R. , J. H. Cate, and C. R. Dickson. Area-Averaged Boundary Layer Winds Derived from an Array of Laser Anemometers. Air Resources Laboratory, Idaho Falls, Idaho. EPA Interagency Agreement IAG-D7-0305. July 1977.

6.1.1.11 NOAA ACOUSTIC SOUNDER

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Funding

EPA Interagency Agreement No. IAG-D4-0305
EPA Contract No. 68-02-2093, Task Order No. 110

Period of Performance

IAG-D4-0305 February 1975 - January 1976
Task Order No. 110 February 1976 - July 1979

Technical Approach

The NOAA Acoustic Sounder program, undertaken as part of the RAPS Boundary Layer Structure Study, was designed to understand and subsequently describe the spatial and temporal variations in the boundary layer caused by varying thermal and mechanical properties of the urban surface. During February 1975, a NOAA Mark VII monostatic acoustic echo sounder system was installed at Upper Air Sounding Network (UASN) Site 141 downtown St. Louis under an interagency agreement with the NOAA Wave Propagation Laboratory (WPL), Boulder Colorado.

The acoustic sounder was a digital design, achieving all of its timing and acoustic signals by dividing down from a stable quartz oscillator. Atmospheric temperature fluctuations up to an altitude of 680 or 1360 meters (range selectable) above the antenna were monitored by measuring backscattered echoes from acoustic tone bursts. The entire acoustic sounder system was comprised of a control unit, a power amplifier, a facsimile recorder, and a four foot parabolic reflector antenna surrounded by an insulated, wooden acoustic shield.

From February 1975 through January 1976, UASN Personnel were responsible for maintaining the sounder system and changing facsimile records while WPL personnel reduced the records and compiled a pattern recognition guide for record reduction. Beginning in February 1976, the contractor (Rockwell International) was assigned complete responsibility for the operation, maintenance, and data reduction of the acoustic echo sounder system.

A complete and detailed logbook covering the acoustic sounder operations was maintained by the contractor. Contained in the logbook were records of inoperative periods, repairs and maintenance performed, scale changes, and any miscellaneous information necessary for interpretation of the recorded data such as sources of unusual noise (air raid siren, helicopter spirals, etc.).

The first stage of data reduction included determination of the pattern types, echo heights, and trace characters from the acoustic sounder records collected at UASN Site 141. Determination of pattern types in hourly segments was in accordance with the NOAA WPL pattern recognition guide as modified by the contractor. The top and bottom of each recorded echo were scaled from the acoustic sounder records in five-minute segments centered on each succeeding half hour. Accompanying each pair of echo heights were codes developed by the contractor for trace character and background noise level.

The second stage of data reduction included the creation of descriptive analyses of both surface and 850 mb synoptic meteorological conditions utilizing daily surface weather maps and microfilm copies of 850 mb maps. The simultaneous radiosonde data from UASN Site 141 were incorporated into the overall data reduction program during the second stages of data reduction, enabling the comparison of radiosonde inversion heights or mixing depths with those measured by the acoustic echo sounder.

All data from the first and second stages of data reduction, except the simultaneous radiosonde data, were coded onto formatted forms and keypunched by the contractor.

Period of Data Collection

The acoustic echo sounder system commenced operations on February 15, 1975 and terminated operations on May 31, 1977.

Parameters Measured	Instrument/Method Used
Acoustic echo returns reflecting turbulent fluctuations of atmospheric temperature	NOAA Mark VII monostatic acoustic radar set to a maximum range of 680 meters. Optional range of 1360 meters not used.

Calibration and Quality Control Procedures

Routine maintenance and calibration of the acoustic echo sounder system included the following:

a. Clean HV bar and pen guide daily.
b. Vacuum carbon residue from inside of recorder weekly.
c. Check power supplies and transmit pulse weekly.
d. Change pens every two weeks.
e. Clean and lubricate roller bearings monthly.
f. Clean drive belts monthly.
g. Blow dust from circuit card monthly.

When troubleshooting was required to isolate a defective component, recalibration of the circuits affected were performed in accordance with the NOAA Technical Manual ERL WPL-12.

Quality control procedures included the development of software checking for erroneous data.

Location and Type of Data Available

Copies of the final report and additional information may be obtained from the EPA Task Coordinator. Data are available as part of the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Owens, E. J. NOAA Mark VII Acoustic Echo Sounder. NOAA Wave Propagation Laboratory, Boulder, Colorado. NOAA Technical Memorandum ERL WPL-12. June 1975.

McElroy, J. L. Detailed Evaluation of Monostatic Acoustical Sounder Determinations of Urban Atmospheric Boundary Layer Structure. Presented at the 1976 Annual Meeting of the Acoustical Society of America, San Diego, California. November 1976.

Waldron, T. L. Acoustic Echo Sounder Operation. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 110 Final Report, EPA Contract 68-02-2093. In preparation.

6.1.2 RADIATION STUDY

6.1.2.1 PENNSYLVANIA STATE UNIVERSITY INSTRUMENTED AEROCOMMANDER

Principal Investigator	Project Officer
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(814) 865-0478	(303) 499-1000 Ext. 6811

Funding EPA Grant No. R800397

Periods of Performance

July - August 1974
February 1975
July - August 1975
July 1976

Technical Approach

Airborne radiation measurements were taken from the Pennsylvania State University (PSU) Aerocommander 680E meteorological research aircraft. The goals of these measurements were:

1. To measure the surface albedo of representative land use areas throughout St. Louis.
2. Evaluate urban-rural variability in solar radiation.

Eppley Precision Spectral Pyranometers were used to measure the global irradiance in three spectral bands: ultraviolet (less than 395 nm wavelength), visible (395 nm to 695 nm) and infrared (greater than 695 nm). Similar sets of pyranometers were also installed on the roofs of RAMS Stations 103, 104, 108, 114, 118 and 122 which encompass both urban and rural areas.

Albedo Measurements -- Specific land use types of interest were rural (field and forest), new residential, old residential, commercial (business districts, railroad yards, etc.) and industrial. To determine the effect of sun angle and building shadow effects, measurements were made at three times during the day: 0800-0900 CST, 1200 CST, and 1500-1600 CST. Since low-level measurements are necessary to minimize atmospheric effects, the flight altitude was about 1000 feet above ground level. High altitude (about 10,000 feet) flights were also made to determine the gross urban-rural effect. Measurements were restricted to nearly cloud-free conditions.

Periods of Data Collection

July 30 - August 21, 1974
February 7 - February 20, 1975
July 22 - August 7, 1975
July 13 - July 26, 1976

Parameters Measured	Instrument/Method Used
Global shortwave irradiance	Eppley Precision Spectral Pyranometer
Long-wave irradiance	Eppley Pyrgeometer
IR temperature	Barnes PRT-5
Total temperature (non-deiced)	Rosemont Engr. Co. 102E2AL
Total temperature (deiced)	Rosemont Engr. Co. 102DL2U
Total temperature (reverse flow)	PSU in-house design
Dewpoint	Cambridge Systems, Inc. 137-C3-S3(P)
Pressure	Rosemont Engr. Co. 830 BA
Indicated air speed	Rosemont Engr. Co. 831A4

Parameters Measured	Instrument/Method Used (continued)
Ground speed	Singer General Precision Doppler Radar GPK-1000
Drift angle	Doppler Radar
Pitch	Rosemount Engr. Co.
Heading	Sperry Gyroscope C-4
VOR heading	Collins Radio Co.
DME	Collins Radio Co. 860-1
Radio altitude	Collins Radio Co. ALT-50

Calibration and Quality Control Procedures

Radiometry was pre-calibrated and post-calibrated against national standards at NOAA facilities in Boulder, Colorado. All other instruments were calibrated and tested prior to each field experiment and periodically during the field operations.

Location and Type of Data Available

Data were recorded on magnetic tapes and are available from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4524

Publication

Grant report was not required.

6.1.2.2 RAMS RADIATION AUDITS

Principal Investigator

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National Oceanic and Atmospheric Administration
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Funding National Oceanic and Atmospheric Administration

Periods of Performance

July - August 1974
February 1975
July - August 1975
July 1976

Technical Approach

These studies were performed with the purpose of providing a check of the RAMS radiation instrumentation and of determining the quality of the radiation measurements. Of particular concern was the reliability of the pyrheliometers' orientation and their ability to track the sun. An additional goal was to insure that all instruments and amplifiers were calibrated properly so that measurements at different sites could be directly compared. In order to accomplish these goals, a technician visited each site nearly daily to check and clean the instruments. In addition, an independent set of four radiometers and a recording system was operated at each of the six RAMS radiation sites. This system included pyranometers which measured global radiation in the ultraviolet (less than 395 nm wavelength), visible (395 nm to 695 nm) and infrared (greater than 695 nm). A pyrheliometer was also part of the system. Data from this independent system were to be compared to the RAPS radiation data both before and after electrical amplification.

Periods of Data Collection

RAMS pyranometers with quartz hemispheres were compared to a reference pyranometer under laboratory conditions from July 28 to August 24, 1974. Preliminary tests of one RAMS pyrheliometer were performed. Surveys of RAMS radiation sites were made and recommendations for improvements were made.

During the following periods, the independent set of four radiometers was operated at the RAMS radiations sites (Stations 103, 104, 108, 113, 117, 122) for a period of 3 to 4 days at each site:

February 1 - February 8, 1975
July 20 - August 10, 1975
July 11 - July 26, 1976

Calibration and Quality Control Procedures

Radiometers were calibrated against national standard instruments based on International Pyrheliometric Scale.

Location and Type of Data Available

Data is in the form of hand written notes and computer printouts and is in the custody of the Principal Investigator.

Publication

Peterson, J. T., and T. L. Stoffel. Urban-Rural Solar Radiation Measurements in St. Louis, Missouri. Air Resources Laboratory, Boulder, Colorado. NOAA Technical Memorandum ERL ARL-76. March 1979.

6.1.3 BOUNDARY LAYER VARIABILITY STUDY

Introduction

The field programs carried out by the University of Wyoming within the framework of RAPS had the primary goal of studying the influence of urbanization on its overriding atmosphere. By making comparative observations of urban and nonurban environments, it was hoped to determine processes responsible for differences in boundary layer structure and wind fields, traceable to urban-induced changes in the physical properties of the atmosphere.

The study periods were in the months of July and August of 1972 through 1976 which coincided with the summer intensive study periods of RAPS. Both spatial and temporal variations of temperature, humidity and wind were measured over the St. Louis metropolitan and surrounding rural areas. In addition, solar radiation and aerosol data were gathered during the field programs. These meteorological and air quality data have been used to document the important perturbations that urbanization exerted upon the planetary boundary layer.

The following subsections summarize the three major field programs carried out by the University of Wyoming.

6.1.3.1 UNIVERSITY OF WYOMING INSTRUMENTED QUEEN AIR

Principal Investigator

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Laramie, WY 82071

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Project Officers

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(702) 736-2969

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Environmental Research Laboratory
Boulder, CO 80302

(303) 499-1000

Funding EPA Grant No. R800875

Period of Performance June 1971 - November 1977

Technical Approach

The University of Wyoming instrumented Queen Air aircraft participated in various experiments that took place over the four separate study periods depending on the prevailing weather conditions. The experiments can be identified as: (1) Air flow study (1972; 1974; 1976) (2) Anomalous thermal wind patterns (1972; 1975) (3) Energy budget (1973) (4) Moisture budget (1974) (5) Radiation study (1974; 1975) (6) Low-level wind field pertubation (1972; 1975) (7) Aerosol heating (1973) (8) Plume monitoring (1974; 1975) (9) Nil city study (1975) (10) Cloud condensation nuclei study (1972; 1973; 1974; 1975) (11) Cumulus study (1972; 1973; 1974) (12) Cumulonimbus study (1972; 1973; 1974; 1975).

Experiments (1) through (9) were especially relevant to the RAPS program. Experiments (10) through (12), designed to study the production of cloud condensation nuclei and the activities of convective clouds, were primarily for project METROMEX which overlapped with RAPS during these periods. Depending on the missions, different flight paths were used. The primary flight paths are shown in Figure 5. Typically, for traverses over the urban-rural complex of St. Louis, the Troy-Pacific flight path was used, and for traverses downwind of the city, the O'Fallon-Belleville transect was used. The transects were usually repeated at different altitudes. Temperature and humidity profiles were accomplished by vertical spirals over local airports.

Periods of Data Collection

During the field program one or more flights might be scheduled on each day. The flight would typically last from one to several hours depending on the mission. Both the meteorological parameters and the positions of the aircraft were monitored continuously during the flight. Ice and cloud nuclei were collected by aluminized mylar bag samplers and analyzed afterwards using a thermal diffusion type counter.

Samples were taken along the flight paths previously mentioned during the following periods:

July 31 - August 25, 1972
August 1 - August 22, 1973
July 25 - August 21, 1974
July 16 - August 6, 1975

Parameters Measured	Instrument/Method Used
Temperature	Rosemount Engineer Sensor Model 102 (de-iced) with a range of -50°C to +50°C. Accuracy of the sensor was ±1°C with a system accuracy of ±0.1°C. Resolution was 0.1°C.
Dew Point	Cambridge Systems Model 137-C3 with a range of -50°C to +50°C. Accuracy of the sensor was ±0.5°C above 0°C and ±1.0°C

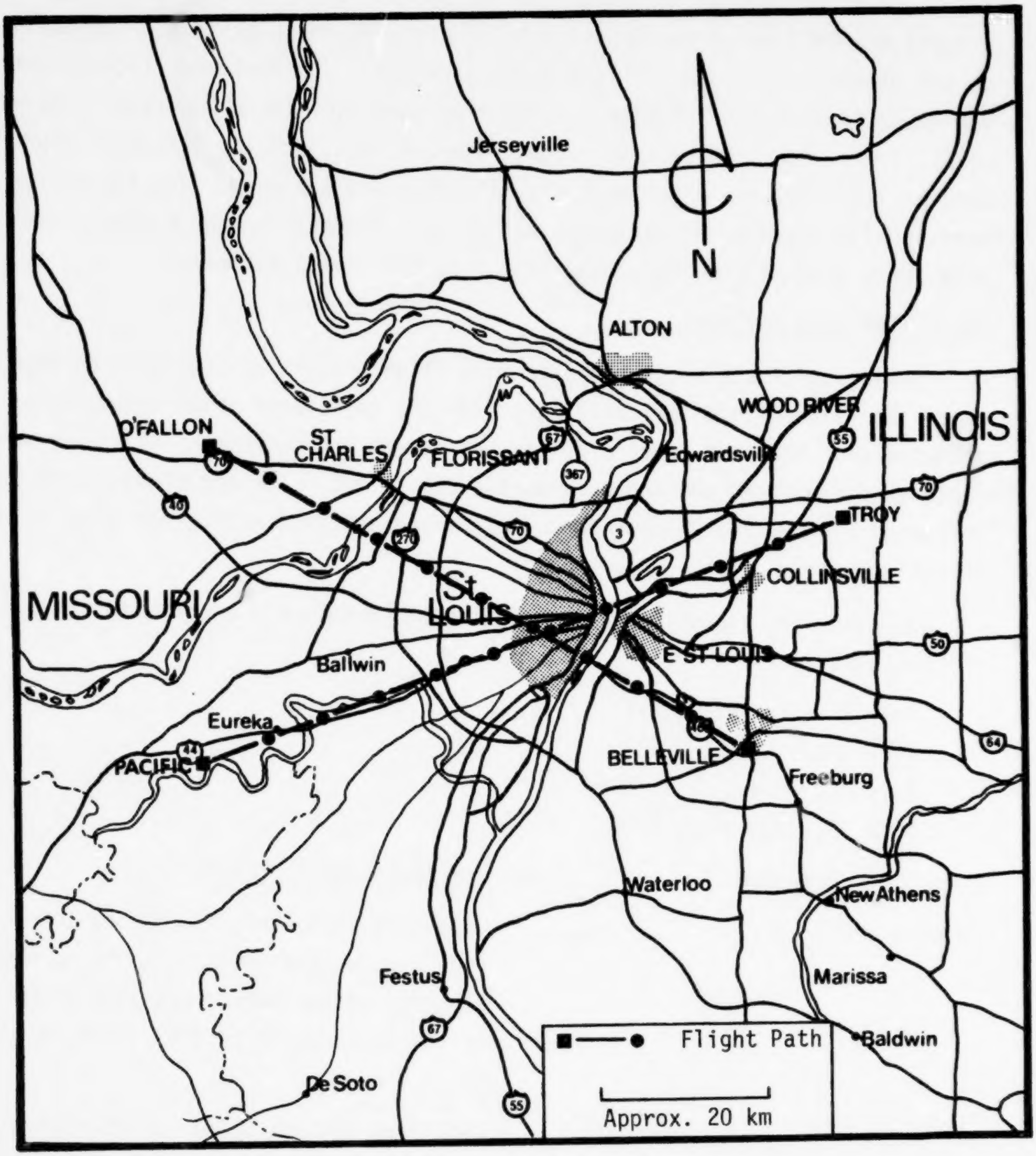

FIGURE 5. PRIMARY UNIVERSITY OF WYOMING FLIGHT TRANSECTS

Parameters Measured	Instrument/Method Used (continued)
Dew Point (continued)	below 0°C with a system accuracy of ±0.1°C. Resolution was 0.1°C.
Heading	King Radio Model KP1550A with a range of 360°. Accuracy of the sensor was ±2° of local magnetic heading with a system accuracy of 1°. Resolution was 1°.
VOR (Azimuth)	King Radio Model KNR-660 with a range of 360°. Accuracy of the sensor was ±2° with a system accuracy of ±1°. Resolution was 1°.
DME	King Radio Model KDM-700 with a range of 0 to 99 nm. Accuracy of the sensor was ±0.1 nm or ±0.2% of range whichever was greater with a system accuracy of ±0.1 nm. Resolution was 0.1 nm.
Altitude	Ball Model 210B Total Pressure Transducer with a range of 0 to 7620 m. Accuracy of the sensor was 0.05% with a system accuracy of 0.1%. Resolution was continuous.
IAS (Indicated Air Speed)	Rosemount Model 1301D Differential Pressure Transducer with a range of 0 to 250 Kts. Accuracy of the sensor was ±2 Kts with a system accuracy of ±1 Kts. Resolution was 1 Kts.
Manifold Pressure	Computer Instruments with a range of 15 to 30" Hg. Accuracy of the sensor was 5% with a system accuracy of ±0.1%. Resolution was 0.1" Hg.

Parameters Measured	Instrument/Method Used (continued)
Angle of Attack	University of Wyoming Atmospheric Research Group Aerovane with a range of 99°. Accuracy of the sensor was 2% with a system accuracy of 2%. Resolution was 0.1°.
Pitch Angle	Smith Industries Ltd-Aviation Division Model 402RGS/-2 with a range of 0 to ±20°/sec. Accuracy of the sensor was 2% with a system accuracy of 2%. Resolution was 0.04° sec^{-1}.
Roll Angle	Smith Industries Ltd-Aviation Division Model 402RGS/-2 with a range of 0 to ±20°/sec. Accuracy of the sensor was 2% with a system accuracy of 2%. Resolution was 0.04° sec^{-1}.
Vertical Acceleration	United Controls Model No. 2152 with a range of ±3 g's. Accuracy was 1% of full range. Resolution was 0.006 g's.
Liquid Water	John Williams Model No. LW11 with a range of 0 to 3 gm m^{3}. Accuracy of the sensor was unknown with a system accuracy of ±0.1 g m^{-3}. Resolution was 0.1 g m^{-3}.
Wind Turbulence	MRI Anemometer
Ice Nuclei	Membrane Filter
Cloud Condensation Nuclei	Membrane Filter
Aitken Nuclei	Garnder counter (type CN)

Calibration and Quality Control Procedures

Before each study period the temperature, dew point and pressure sensors were calibrated both against tower measurements at the Jefferson County Airport (Broomfield, CO) and the apparatus aboard the NCAR Buffalo aircraft in a formation flight.

Location and Type of Data Available

Data collected by the University of Wyoming group are stored on magnetic tapes compatible with IBM-computers and will be available to researchers through the RAPS Data Bank. For more information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Auer, A. H. Jr., and J. M. White. Inadvertent Weather Modification by Urban Pollution - Final Report. University of Wyoming, Laramie, Wyoming. EPA Grant No. R-800875. November 1977.

6.1.3.2 UNIVERSITY OF WYOMING MOBILE PIBAL AND RADIOSONDE SUPPORT

Principal Investigator	Project Officers
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	James T. Peterson National Oceanic and Atmospheric Administration Environmental Research Laboratory Boulder, CO 80302 (303) 499-1000

Funding EPA Grant No. R800875

Period of Performance June 1971 - November 1977

Technical Approach

The experiments performed by the University of Wyoming pilot balloon team were designed to document the urban perturbation to the wind field. The data collected would also be used for verification of selected airflow and cumulus simulation models. Selected locations both upwind and downwind of the St. Louis urban complex (Pacific and St. Charles) and also near the city center (Gateway Arch) were used for pibal measurements.

Two radiosonde launch sites were used by the University of Wyoming. Pacific, MO was selected as representative of conditions upwind from the St. Louis urban complex, while the St. Louis riverfront radiosonde site near the Gateway Arch gave conditions representative within the center of the urban complex.

Periods of Data Collection

The observation periods for the pilot balloons (30g and 100g) coincided roughly with the aircraft flights. Radiosondes were launched around sunrise, sunset, and midday as well as during flight times. The duration of the pibal track averaged about 15 min, with the shortest on the order of 5 min and the longest lasting about half an hour. Most of the radiosondes were tracked to levels between 700 and 100 mb. Observations were taken during the following periods:

July 31 - August 25, 1972
August 1 - August 22, 1973
July 25 - August 21, 1974
July 16 - August 6, 1975

Parameters Measured	Instrument/Method Used
Wind speed and wind direction	Single theodolite method. Calculated wind speed and direction from angular values observed at a constant time interval of 30 seconds.
Temperature, relative humidity, wind direction and wind speed aloft	VIZ 1680 MHz radiosonde equipped with a standard thermistor, hygristor and baroswitch. The unit was tracked with a portable winds-aloft measurement system.

Calibrations and Quality Control Procedures

Since the pibal height depends on the assumed ascent rate of the balloon when using a single-theodolite system, several double-theodolite system releases were made with the intent of calibrating the rise rate used in the single theodolite work. This investigation led to the discovery of some interesting relationships between the ascent rates and the ambient temperature lapse rates.

Location and Type of Data Available

The University of Wyoming pibal and sounding data are stored on magnetic tapes compatible with IBM-computers and will be available to researchers through the RAPS data bank. For information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Boatman, J. F. The Effect of Tropospheric Temperature Lapse Rates on the Ascent Rates of Pilot Balloons. Journal of Applied Meteorology, 13:955, 1974.

Auer, A. H. Jr., and J. M. White. Inadvertent Weather Modification by Urban Pollution - Final Report. University of Wyoming, Laramie, Wyoming. EPA Grant No. R-800875. November 1977.

6.1.3.3 UNIVERSITY OF WYOMING INSTRUMENTED SURFACE VEHICLES

Principal Investigator

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(307) 766-3245

Project Officers

James L. McElroy
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James T. Peterson
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Environmental Research Laboratory
Boulder, CO 80302

(303) 499-1000

Funding EPA Grant No. R800875

Period of Performance June 1971 - November 1977

Technical Approach

The University of Wyoming instrumented mobile units complemented the aircraft and pibal operations by supplying the surface wind, temperature and humidity data. They also collected precipitation samples and served as convenient platforms for pibal observations. They carried multipoint chart recorders which provided output immediately available for the operators so that meteorological changes and trends could be observed.

Periods of Data Collection

Measurements were taken during the following periods to complement the aircraft observations:

July 31 - August 25, 1972
August 1 - August 22, 1973
July 25 - August 21, 1974
July 16 - August 6, 1975

During the field program the mobile units were used to make transects for temperature and humidity across the Metropolitan St. Louis area. They were also deployed to strategic locations in and around St. Louis for surface wind and pibal observations. The temperature, dew point, wind speed and wind direction were recorded continuously during the observation periods.

Parameters Measured	Instrument/Method Used
Temperature	Rosemount 104C platinum resistance sensor (ventilated) with a range of -50°C to +50°C. System resolution was 0.1°C with an accuracy of ±0.2°C.
Dew point	Cambridge Model 880 dew point sensor with a range of -40°C to +50°C. System resolution was 0.3°C with an accuracy of ±2.0°C.
Wind speed	RAIN No. 436 anemometer with a range of 1.6 to 160 mph. System resolution was 3.2 mph with an accuracy of ±5%.
Wind direction	RAIN No. 437 vane with 16 point resolution.
Wind Sounding	Single theodolite
Atmospheric pressure	Belfort Model 355R remote microbarograph with a range of 650 to 1050 mb resolving 0.5 mb.
Air filter samples	3 x 3 sequential sampler with differential pressure transducer with a rate of 20 liters per minute per filter. Accuracy ±5% of volume sampled.

Parameters Measured	Instrument/Method Used (continued)
Raindrop - size distribution	Rd -60 momentum sensor with 20 size group resolution of drops between 0.3 and 10 mm in diameter. Accuracy was ±5%.
Rate of rainfall	Stand-tube with discharge nozzle capable of transient rainfalls up to 200 mm per hour. Resolution is 3 mm per hour and accuracy is ±5% at the high rate.
Rain and hail collection	1) Replacable bags 15 ft. above ground 2) Hailstones quenched to dry-ice temperature

Calibration and Quality Control Procedures

The temperature and dew point sensors were calibrated against an Assmann psychrometer once a week during the field study. The sensors on the two mobile units were also mutually compared before and after each mission. The anomometer was checked by driving the vehicle at specified speeds during calm periods.

Location and Type of Data Available

Data collected by the mobile units will be available, after reduction from strip charts, on magnetic tapes through the RAPS data bank. For more information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Auer, A. H. Jr., and J. M. White. Inadvertent Weather Modification by Urban Pollution - Final Report. University of Wyoming, Laramie, Wyoming. EPA Grant No. R-800875. November 1977.

6.2 BOUNDARY LAYER DYNAMICS

6.2.1 BOUNDARY LAYER ENERGETICS STUDY

6.2.1.1 EPA MOBILE FLUXATRONS

Principal Investigator

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Task Coordinators

Jason K. S. Ching (MD-80)
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(919) 541-4524

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(702) 736-2969

Funding

EPA Contract 68-02-1081, Task Order No. 60
EPA Contract 68-02-2093, Task Order Nos. 109, 116

Periods of Performance

Task Order No. 60	July - August 1975
Task Order No. 109	February - March 1976
Task Order No. 116	July - September 1976

Technical Approach

As part of the RAPS Boundary Layer Energetics Study conducted in the St. Louis Metropolitan Area, EPA mobile fluxatrons were used to derive the sensible heat flux term of the energy balance equation by integrating the product of the coincidental measurements of turbulent vertical velocity and temperature fluctuations.

Periods of Data Collection

Task Order No. 60	July 16 - August 15, 1975
Task Order No. 109	February 15 - March 10, 1976
Task Order No. 116	July 20 - August 13, 1976

Parameters Measured	Instrument/Method Used
Ambient Air Temperature	A fast response temperature sensor using a thermistor and a voltage resistance network.
Sensible Heat Flux	A "fluxatron" type analog circuitry of inhouse design to integrate the product of the coincident turbulent vertical velocity and temperature fluctuation measurements.
Turbulent Temperature Data	Fenwall model G112 thermistors mounted on two glass hermetic seals with a time constant of one second. Circuitry of inhouse design.
Vertical Wind Velocity	R. M. Young Model 27004 Gill UVW Anemometer with a range of 0-30 m/s for axial flow and 0-22 m/s for all angle flow with a 23 cm x 30 cm propeller. The threshold sensitivity of the propeller was 0.1-0.2 m/s with a distance constant of 1.0 m where the distance constant equals the wind passage for 63% recovery from step change in wind speed.

Parameters Measured	Instrument/Method Used (continued)
Wind Speed and Direction	Climet Model CI-25 wind measurement system with a Model 011-1 wind speed transmitter and Model 012-10 wind direction transmitter. The anemometer had a threshold of 0.6 mph, accuracy of ±1% or 0.15 mph and a range of 0-100 mph. The wind direction sensor had a damping ratio of 0.4 and a threshold of 0.75 mph. The accompanying portable translator was battery/AC operated with switch selectable ranges of 0-25, 0-50 and 0-100 mph. It was normally operated in the 0-50 mph mode.
Net Radiation	Swissteco Model S-1 net pyrradiometer. Spectral range was from 0.3 to 60 microns. Sensitivity was approximately 0.5 mv/mw cm^2. Time constant was 30 seconds for 98% of full scale.
Dry and Wet Bulb Temperatures	Measured using a standard National Weather Service sling psychrometer.
Turbulent Fluctuations of Water Vapor Content in Air	Electromagnetic Research Corporation Lyman Alpha BLR Humidiometer. The method of operation involves a source tube generating a beam of Lyman-Alpha radiation, emerging from a special UV window, crossing the measuring path, and entering a nitric oxide ionization chamber detector. The Lyman-Alpha radiation ionizes the nitric oxide, causing a detectable current amplified to an output meter. The temperature range of the sensor head was -55°C to

Parameters Measured	Instrument/Method Used (continued)
	+55°C and the control unit temperature range was -20°C to +60°C.
Wind Speed and Wind Direction Aloft	10 gram pilot balloon (pibal) observations using the single theodolite method. Calculated wind speed and wind direction from angular values observed at a constant time interval of 30 seconds.

Calibration and Quality Control Procedures

Before each experiment, the fluxatrons and wind systems were assembled and allowed proper warm-up time before calibration. Calibration procedures included zero reference and span adjustments for each recording scale, and adjustments to prevent recorder drift. All notations were recorded in logbooks. During operation all recorders were maintained on proper recording scales and charts were time annotated for identification. Any necessary scale changes, adjustments, records of hourly zero checks, malfunctions, or other pertinent information were recorded in logbooks.

Except for the minimum observation being five minutes (weather permitting), all pibals were released in accordance with Upper Air Sounding Network procedures (Section 4.0). A compass was used at each site to determine magnetic north. A reference point for true north was then established by correcting for the appropriate magnetic declination angle, obtained from U. S. Geological Survey maps.

Quality control procedures included reviewing elevation and azimuth angles for angular continuity and checking for correct magnetic declination. Theodolite orientation was checked before and after each pibal release.

Location and Type of Data Available

After the Task Order No. 109 experiments were completed, the data collected from both Task Order Nos. 60 and 109 were found invalid due to unbalanced bridge systems in the fluxatron units. This problem was corrected before the start of Task Order No. 116, therefore only the Task Order No. 116 data is considered valid. Additional information may be obtained from the EPA

Task Coordinator. Valid data is available on magnetic tape as part of the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Waldron, T. L. Summer 1975 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 60 Final Report, EPA Contract 68-02-1081. January 1976.

Waldron, T. L. St. Louis Winter 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 109 Final Report, EPA Contract 68-02-2093. May 1976.

Waldron T. L. St. Louis Summer 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 116 Final Report, EPA Contract 68-02-2093. May 1977.

6.2.1.2 SUBSURFACE HEAT FLUX STUDY

Principal Investigator	Task Coordinator
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(314) 567-6722	(919) 541-4524

Funding EPA Contract No. 68-02-2093, Task Order No. 104

Period of Performance September 1975 - January 1978

Technical Approach

This task was undertaken in support of the RAPS Boundary Layer Structure and Energetics Studies. Information on the heat flux at the earth/air interface along with net radiation measurements would serve to define the components of the atmospheric energy budget. Combined with the RAPS land use inventory, these measurements would also provide boundary and initial conditions for use in mathematical dispersion formulations.

The subsurface heat flux study was designed to measure the storage term of the energy balance equation. A network of thermistors was implanted at the St. Charles County Airport in and below an area of the concrete runway, in and below a black painted area of the concrete runway and in a grassy area adjacent to the runway. Net radiometers were installed above each surface area. Additional equipment to measure wind speed and direction, barometric pressure, dew point and precipitation were also installed at the site.

Period of Data Collection

The subsurface heat flux study at St. Charles County (Smartt Field) Airport was operational between January 27, 1976 and May 31, 1977. The data acquisition system recorded instantaneous values each minute while the barometric pressure, shelter temperature (hygrothermograph), precipitation were continuously recorded.

Parameters Measured	Instrument/Method Used
Subsurface Temperature	Yellow Springs Instrument Co. Model 401 temperature probe with a time constant of 7.0 seconds.
Surface Temperature	Yellow Springs Instrument Co. Model 408 "banjo" thermistor with a time constant of 0.6 seconds.
Ambient Air Temperature	Yellow Springs Instrument Co. Model 401 temperature probe housed in a homemade radiation shield. Time constant was 7.0 seconds. One Bendix Friez recording hygrothermograph measuring in degrees Fahrenheit (the humidity portion of the instrument was non-operational).
Net Radiation	Swissteco Model S-1 net pyrradiometer. Spectral range was from 0.3 to 60 microns. Sensitivity was approximately 0.5 mv/mw cm^2. Time constant was 30 seconds for 98% of full scale.
Barometric Pressure	Weather Measure Corporation Model B211 recording microbarograph. Sensitive to pressure changes of 0.005 inches of mercury with a lag time of 0.1 seconds. Accuracy of ±0.005 inches of mercury. Range was 945 to 1045 mb.
Precipitation	Weather Measure Corporation Model P511-E tipping bucket rain gauge with event recorder Model P521. Accuracy was 0.5% at 0.5 inches per hour. Calibrated for 0.01 inch increments.

Parameters Measured	Instrument/Method Used (continued)
Wind Speed and Direction	Climet Model CI-25 wind measurement system with a model 011-1 wind speed transmitter and model 012-10 wind direction transmitter. The anemometer has a threshold of 0.6 mph, accuracy of ±1% or 0.15 mph and a range of 0-100 mph. The wind direction sensor had a damping ratio of 0.4 and a threshold of 0.75 mph. The accompanying portable translator was battery/AC operated with switch selectable ranges of 0-25, 0-50 and 0-100 mph. It was normally operated in the 0-50 mph mode.
Dew Point	EG&G International Model 880 optically sensed, thermoelectrically cooled, condensation dew point hygrometer. Range was from -40°C to +50°C with a maximum depression capability of 45°C at an ambient temperature of 27°C. Resolution was 0.25°C with a nominal accuracy of 1°C.
Soil Moisture	Cores of soil approximately 21 mm in diameter were removed from the area adjacent to the runway and divided to correspond with the placement of the subsurface thermistors. These segments were then weighed, dehydrated in an oven for 24 hrs at 105°C, and reweighed to obtain the water content.
Thermal Conductivity and Heat Capacity of Soil and Concrete Samples	The thermal diffusivity of each sample was derived by a heating and cooling probe technique developed at the U. S.

Parameters Measured	Instrument/Method Used (continued)
	Army Corp of Engineers Cold Regions Research and Engineering Laboratory. This technique with multiple runs is accurate to ±3%. Heat capacities were measured by standard calorimetric procedures using a sapphire as a comparative material.

Data from the thermistors, wind system and dew point hygrometer were recorded by a Digitem data acquisition system interfaced to a Kennedy incremental seven track tape recorder.

Table 9 summarizes the equipment used and the effective measurement height.

Calibration and Quality Control Procedures

The subsurface and ambient air temperature thermistors were calibrated by the EPA at Research Triangle Park prior to their installation. The net pyrradiometers were calibrated before, during and after the field study. The post calibration by an independent testing laboratory indicated the difference between the pre and post calibration was less than 5%. Wind speed was checked with a hand held wind gauge while the recording microbarograph was compared to a portable aneroid barometer. The hygrothermograph's temperature readings and the hygrometer's dewpoint measurements were occasionally checked with a sling psychrometer.

All thermistor data were checked during computer processing by cross level comparisons. Suspect thermistors were promptly replaced.

Location and Type of Data Available

Data are available from the RAPS data bank. For information on its availability contact:

TABLE 9. SUBSURFACE HEAT FLUX STUDY EQUIPMENT PLACEMENT

Sensor/Instrument	Height	Concrete Area	Black Paint Concrete Area	Grassy Area	Station Shelter
Net Pyrradiometer	1.5 m AS	X	X	X	
Shielded Thermistor	4.0 m AS			X	
Shielded Thermistor	1.0 m AS	X	X	X	
Surface Thermistor	SURFACE	X	X	X	
Subsurface Thermistor	1.0 cm BS	X	X	X	
Subsurface Thermistor	3.0 cm BS	X	X	X	
Subsurface Thermistor	5.0 cm BS	X	X	X	
Subsurface Thermistor	7.0 cm BS	X	X		
Subsurface Thermistor	10.0 cm BS	X	X	X	
Subsurface Thermistor	15.0 cm BS			X	
Subsurface Thermistor	18.0 cm BS	X	X		
Subsurface Thermistor	20.0 cm BS			X	
Subsurface Thermistor	22.0 cm BS	X	X		
Subsurface Thermistor	30.0 cm BS	X		X	
Subsurface Thermistor	40.0 cm BS	X			
Subsurface Thermistor	50.0 cm BS	X		X	
Wind System	4.0 m AS			X	
Hygrothermograph	1.0 m AS			X	
Rain Gauge	0.5 m AS	X			
Hygrometer	1.0 m AS			X	
Microbarograph	2.0 m AS				X

AS = above surface BS = below surface

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Additional information as well as copies of the final report which contain the thermal diffusivity data are available from the EPA Task Coordinator.

Publication

Strothmann, J. A. Subsurface Heat Flux Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 104 Final Report. July 1979.

6.2.1.3 RAMS TOWER TURBULENCE STUDY

Principal Investigator	Task Coordinators
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Funding EPA Contract No. 68-02-2093, Task Order Nos. 116, 118

Periods of Performance

Task Order No. 116	July - August 1976
Task Order No. 118	October - November 1976

Technical Approach

In order to provide a better understanding of the turbulence structure and energy balance of the air overriding the St. Louis urban/rural complex, five selected RAMS towers (105, 107, 109, 111, and 113) were instrumented to measure temperature and three-component wind velocity fluctuations. The temperature and wind velocity fluctuations were measured by fast response temperature sensors and UVW propeller anemometers located at the tops of the 100-foot towers. Subsequent processing of these data yielded turbulent momentum and sensible heat fluxes by the eddy correlation technique.

Periods of Data Collection

The measurements were made at the five RAMS stations during the summer 1976 period, but only RAMS towers at Sites 105, 107, and 109 were instrumented for the fall 1976 intensive. Both the temperature and the wind velocity components were monitored continuously during the study period. These fast-response sensor data were recorded at half-second intervals on magnetic tapes.

The orientations of the anemometers were determined by the surveyor's transit bearings for the "U" arms. They are given with respect to the magnetic north separately for the two intensive periods as follows:

Operation Period	Station	"U" Arm Orientation
7/20/76 - 8/30/76	105	225° 12'
7/20/76 - 8/30/76	107	224° 26'
7/20/76 - 8/30/76	109	225° 47'
7/21/76 - 8/30/76	111	225° 35'
7/21/76 - 8/30/76	113	226° 02'
10/26/76 - 11/19/76	105	279° 45'
10/26/76 - 11/19/76	107	280° 00'
10/26/76 - 11/19/76	109	279° 45'

Parameters Measured	Instrument/Method Used
Air temperature fluctuation	Fenwall fast-response thermistor (time constant = 0.2 sec)
Fluctuations of wind velocity components	Gill UVW propeller anemometer with shaft extenders, by R.M. Young Company

Calibration and Quality Control Procedures

Calibration of the thermistors was performed every two or three days using coefficients supplied by EPA. To perform a calibration, the input thermistor probe was removed and replaced by the resistance box. Appropriate resistance values corresponding to 0° and 25°C were set on the resistance box and resultant voltage output values recorded. The voltage values were used with the coefficients to solve a set of conversion equations. Both values were then adjusted as necessary to bring the instrument back into proper calibration and the final value was recorded. As a check the ambient temperature was also derived using the coefficients and equations are compared to the RAMS station value.

Two point calibrations were performed on the UVW anemometers. Zero data were obtained by taping the three propellors to prevent any movement. Calibration data were recorded in this mode for about twenty hours. Calibration at

1800 RPM was also obtained by clockwise and counter clockwise rotation of each propellor. Data were recorded in this mode for at least an hour at each station.

Location and Type of Data Available

The RAMS tower turbulence data were recorded as digitized output voltages on magnetic tapes at half-second intervals. Inquiries regarding these data should be directed to:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Waldron T. L. St. Louis Summer 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 116 Final Report, EPA Contract 68-02-2093. May 1977.

Waldron, T. L. St. Louis Fall 1976 Boundary Layer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 118 Final Report, EPA Contract 68-02-2093. March 1977.

6.2.1.4 PENNSYLVANIA STATE UNIVERSITY INSTRUMENTED AEROCOMMANDER

Principal Investigator	Project Officer
Dennis W. Thomson Department of Meteorology The Pennsylvania State University University Park, PA 16802	James T. Peterson National Oceanic and Atmospheric Administration Environmental Research Laboratory Boulder, CO 80302
(814) 865-0478	(303) 499-1000 Ext. 6811

Funding EPA Grant No. R800397

Periods of Performance

July - August 1974
February 1975
July - August 1975
July 1976

Technical Approach

Eppley Precision Spectral Pyranometers on the Pennsylvania State University Aerocommander 680E aircraft (Section 6.1.2.1) were used to measure the vertical variation of solar radiation and thereby to study the effect of pollutants on atmospheric heating and cooling rates. During each flight two vertical profiles were mapped, one in relatively clean air upwind of the city and one in dirty downwind conditions. Each profile started at approximately 10,000 feet altitude. During descent, the aircraft leveled off for about one minute of measurements at 1000 feet intervals above the haze and 500 feet intervals within the haze. The lowest measurement was at approximately 500 feet.

Vertical radiation profiles were also taken with the EPA/RAPS instrumented helicopters. Refer to Section 5.0, Aerial Monitoring System, for further details.

Periods of Data Collection

July 30 - August 21, 1974
February 7 - February 20, 1975
July 22 - August 7, 1975
July 13 - July 26, 1976

Parameters Measured	Instrument/Method Used

For solar radiation and aircraft state parameters, see Section 6.1.2.1. For aerosol measurements the following additional instruments were used:

Aerosol size distribution	Royco Counter
Condensation nuclei	Environment-One
Scattering coefficient	MRI Nephelometer

Calibration and Quality Control Procedures

Radiometry was pre-calibrated and post-calibrated against national standards at NOAA facilities in Boulder, Colorado.

Location and Type of Data Available

Radiation data were recorded on magnetic tapes and are available from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4524

Aerosol data may be obtained from the Principal Investigator.

Publication

Grant report was not required.

6.2.1.5 RAPS AREA LAND-USE INVENTORY

Principal Investigator	Project Officer
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Funding EPA Contract No. 68-02-2476

Period of Performance September 1976 - August 1977

Technical Approach

The land-use patterns in the metropolitan St. Louis area are classified into the following categories: water, marsh/swamp, thick grass, thin grass, farmland, light density residential (with and without trees), medium density residential, central business district, industry/railway, and forest. The LANDSAT Satellite imagery data were calibrated by means of selected ground truth data for each land-use category.

Parameters Measured	Instrument/Method Used
Land Use Pattern	The percentage occupation for each land-use category was determined for both a high-resolution (1 km x 1 km) grid in the central RAPS area, and a lower-resolution (10 km x 10 km) grid for the entire RAPS area and surroundings using LANDSAT imagery. Terrain height and mean terrain slope were also determined for both grids.

Calibration and Quality Control Procedures

Ground truth data were collected to verify various areas of land use patterns.

Location and Type of Data Available

Parameters as described above should be available through the RAPS Data Bank and may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

No contract final report has yet been filed.

6.2.2 BOUNDARY LAYER TRACER STUDY

6.2.2.1 CALIFORNIA INSTITUTE OF TECHNOLOGY SF_6 TRACER RELEASE

Principal Investigator

Frederick H. Shair
Department of Chemical Engineering
California Institute of Technology
Pasadena, CA 91125

(213) 795-6811

Project Officer

Francis A. Schiermeier (MD-80)
c/o Environmental Protection Agency
Environmental Sciences Research
Laboratory
Research Triangle Park, NC 27711

(919) 541-2649

Funding EPA Grant No. R804990010

Period of Performance October 1976 - September 1978

Technical Approach

Seven atmospheric tracer tests were conducted in St. Louis between November 8 and 14, 1976. The purpose of these tests was to examine the transport and dispersion of pollutants from a tall stack during unstable meteorological conditions.

During these tests, 2017 grab samples were analyzed from 92 airborne traverses, 3411 grab samples from 80 automobile traverses, and 613 hourly averaged air samples from 9 stationary locations. A total of 6040 air samples were analyzed during the seven field tests.

To help locate the plume's movement and to guide the airborne and automobile traverse teams to the plume area, pibals and tetroons were released hourly near the SF_6 release site (Sections 6.2.2.2 and 6.2.2.3).

Period of Data Collection

November 8-14, 1976

Parameters Measured	Instrument/Method Used
Sulfur Hexafluoride Concentration	Samples were analyzed by electron capture chromatography, using a Loenco Model 70 portable gas chromatograph, equipped with a Spectra Physics Autocab System I Integrator.

Samples were collected from the roofs of RAMS stations during automobile traverses and aircraft flights. To obtain continuous air sampling at stationary ground locations, nine hourly-sampling syringe units were installed on the roofs of RAMS Stations 102, 110, 112, 114, 115, 117, 119, 120, and 121. Each air sampling unit consisted of a timing mechanism (electrically driven) and twelve syringes mounted on a board. The calibrated timing mechanism allowed the plunger of each syringe to be sequentially retracted, drawing air into the syringe reservoir over a period of one hour. These sampling units provided hourly averaged air samples for SF_6 analysis for twelve consecutive hours (from 2-3 hours before tracer release to 4-5 hours after release termination) at each of the selected RAMS stations.

For automobile traverses, grab samples were collected in 30 cm^3 plastic syringes. A similar system was used for airborne sampling.

Calibration and Quality Control Procedures

The chromatographs were calibrated using an exponential dilution system. The detection limit was approximately 10^{-12} parts SF_6 per part of air.

During the sampling period, the SF_6 chromatographs were cross-checked against each other with a constant concentration sample. The cross-check results indicated that the response characteristics of the chromatographs had a probable uncertainty of ±15% with ±24% in the worst case.

Location and Type of Data Available

Some raw data are contained in the preliminary report referenced below. All of the SF_6 measurements will be stored in the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Derus, M., B. K. Lamb, and F. H. Shair. Development and Application of Multiple Tracer Techniques for the Study of Pollutant Transport and Dispersion in the Atmosphere: Transport and Dispersion from Tall Stacks under Unstable Meteorological Conditions. California Institute of Technology, Pasadena, California. Preliminary Report, EPA Grant R804990010. February 1977.

6.2.2.2 MOBILE PIBAL SUPPORT

Principal Investigator	Task Coordinator
Timothy L. Waldron Rockwell International Air Monitoring Center 11640 Administration Drive Creve Coeur, MO 63141	Francis A. Schiermeier (MD-84) c/o Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711
(314) 567-6722	(919) 541-2649

Funding EPA Contract No. 68-02-2093, Task Order No. 119

Period of Performance November - December 1976

Technical Approach

As part of the RAPS Boundary Layer Tracer Study conducted in the St. Louis Metropolitan Area during November 1976, low level wind profiles, obtained by releasing pilot balloons (pibals), were used to define the available transport winds.

Period of Data Collection

Pibal observations were taken at one-half hour intervals during daytime hours from November 7-14, 1976. Three pibals were released on November 7 before a planned experiment was cancelled due to high winds. All observations were taken at the Labadie power plant near Labadie, Missouri with one day of exception when the pibals were released from RAMS Station 121 in North St. Louis County.

Parameters Measured	Instrument/Method Used
Wind speed and wind direction	10 gram pilot balloon (pibal) observations using the single theodolite method. Calculated wind speed and wind direction from angular values observed at a constant time interval of 30 seconds.

Calibration and Quality Control Procedures

Except for the minimum observation being five minutes (weather permitting), all pibals were released in accordance with Upper Air Sounding Network procedures (Section 4.0). A compass was used at each site to determine magnetic north. A reference point for true north was then established by correcting for the appropriate magnetic declination angle, obtained from U.S. Geological Survey maps.

Quality control procedures included reviewing elevation and azimuth angles for angular continuity and checking for correct magnetic declination. Orientation was checked before and after each pibal release.

Location and Type of Data Available

Copies of the task order final report and additional information may be obtained from the EPA Task Coordinator. Data are available on magnetic tape as part of the RAPS data bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Waldron, T. L. November 1976 SF_6 Tracer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 119 Final Report, EPA Contract 68-02-2093. May 1977.

6.2.2.3 NOAA/ARL TETROON RELEASES

Principal Investigators	Project Officer
C. Ray Dickson National Oceanic and Atmospheric Administration Air Resources Laboratory Idaho Falls, ID 83401 (208) 526-2328	Francis Pooler, Jr. (MD-84) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-2649

James K. Angell
Walter H. Hoecker
National Oceanic and Atmospheric
Administration
Air Resources Laboratory
Silver Spring, MD 20910

(301) 427-7645

Funding EPA Interagency Agreement No. D7-0305

Period of Performance November 1976

Technical Approach

In support of the RAPS Boundary Layer Tracer Study conducted in the St. Louis Metropolitan Area during November 1976, tetrahedral balloons (tetroons) were used to define the existing transport wind.

Period of Data Collection

Tetroons were released each day from the SF_6 tracer release site for the period November 7-14, 1976. For each period of operation during the tracer study, approximately six tetroons were released and tracked with an M-33 radar. The tetroon release interval was hourly, with two or three tetroons released before, three during, and one after the SF_6 release.

Parameters Measured	Instrument/Method Used
Transport Wind	Released tetrahedral balloons (tetroons) from the SF_6 tracer release site to define the existing transport wind in real-time. The tetroons with attached transponders were tracked by means of M-33 radar. Sketches of the radar's Planned Position Indicator (PPI) scope showing tetroon locations were drawn by the radar observer.

Calibration and Quality Control Procedures

Before release, the tetroons were super-pressurized to 20 or 30 millibars, enabling them to float aloft at nearly constant altitudes.

Location and Type of Data Available

The tetroon data are in the form of PPI scope sketches and have not been reduced to a computer compatible format. Information concerning data collection and available data may be obtained by contacting the EPA Project Officer.

Publication

Final report was not required.

6.2.3 HIGH LEVEL VERTICAL FLUX STUDY

Introduction

A field program was carried out in and around the St. Louis Metropolitan Area in 1975 in conjunction with the Regional Air Pollution Study (RAPS) and the Metropolitan Meteorological Experiment (METROMEX). Its principal purpose was to provide detailed information on the three-dimensional airflow in the planetary boundary layer over a metropolitan area.

Because of the differences in the surface roughness and temperature of urban versus rural terrains, both the mean winds and the turbulent components of the air motion are expected to vary over a region including an urban complex. Of particular interest, from the point of view of boundary layer meteorology and regional dispersion modeling, are the vertical wind profiles and the vertical fluxes of momentum, heat, moisture, and aerosols as well as their associated exchange coefficients.

Three separate but closely coordinated field efforts were designed to address different aspects of the problem. They were implemented during the months of February and July 1975 so as to study conditions in both winter and summer. They are summarized in the following subsections.

6.2.3.1 NCAR INSTRUMENTED QUEEN AIR

Principal Investigator	Project Officer
Bernice Ackerman Atmospheric Sciences Section Illinois State Water Survey Urbana, IL 61801 (217) 333-2210	James L. McElroy Environmental Protection Agency Environmental Monitoring and Support Laboratory Las Vegas, NV 89114 (702) 736-2969

Funding EPA Grant No. R803682

Period of Performance February 1975 - December 1976

Technical Approach

An instrumented Queenair 306 airplane, pilot, and technician were provided by the Research Aviation Facility of NCAR. The Queenair carried instruments that measured the three components of wind velocity, and high frequency fluctuations in velocity, temperature and humidity, as well as standard state parameters and aircraft position.

Depending on the particular field experiments, or missions, the aircraft executed various flight patterns. Generally, straight alongwind and crosswind flight paths were used to map the fields of temperature, moisture, wind, turbulence intensity, and vertical fluxes as well as to estimate vertical exchange coefficients and their variations with height. These paths were usually quite long so as to cover both St. Louis city and the adjoining rural areas, and were repeated at different elevations. Closed circular or triangular flight paths were used to determine the nocturnal urban heat island circulation and its strength. Circuits around the city and metropolitan area were also accompanied by closed rectangular and triangular flight patterns over a predominantly rural area.

Periods of Data Collection

February 17-28, 1975
July 1-31, 1975

The only major difference in instrumentation between the February and the July operations was the addition of the condensation nuclei counter in July.

Parameters Measured	Instrument/Method Used
Air temperature	NCAR reverse-flow thermometer (slow response - a few seconds)
Air temperature	Rosemount platinum resistance thermometer (medium response - a few tenths of a second)
Air temperature fluctuation	NCAR "K-probe", platinum resistance thermometer
Dew-point temperature	Cambridge dew-point hygrometer
Atmospheric refractive index	NCAR microwave refractometer
Cloud liquid water content	Johnson-Williams liquid water content meter
Concentration of condensation nuclei (July only)	Environment I nuclei counter
Radiation-temperature (analog IR)	Barnes PRT-5
Land use patterns	Downward-viewing time lapse movies, one frame every 4 seconds
Altitude	Static pressure probe (transducer)
Altitude (less than 1 km only)	Radio altimeter
Airspeed	Wing-mounted Rosemount pitot Boom-mounted pitot and transducer
Orientation to airstream	Angle of attack, fixed vane Angle of attack, rotating vane Sideslip angle, fixed vane

Parameters Measured	Instrument/Method Used (continued)
Boom accelerations	Vertical and lateral accelerometers (boom-mounted)
Aircraft velocity relative to ground; INS - computed latitude and longitude	Inertial Navigational System (INS)

Calibration and Quality Control Procedures

The thermometers were calibrated in a standard temperature bath. For the resistance thermometers, verification was also done with fixed resistors. The dynamic heating effects were determined by flying the aircraft at different controlled speeds.

The main wind instruments used in the study were the boom-mounted fixed vanes and the rotating vane used as an alternative. These provided the fluctuating wind velocity components required for calculating the fluxes. They were calibrated using a strain gauge bridge circuit. Bench tests were performed in which calibrated weights were correlated to the output voltages. The vanes were also tested in the Air Force Academy wind tunnel facility at Colorado Springs before the program started.

Sensitivity calibration for the refractometer (humidity fluctuation) was provided by NOAA. Its offset was further determined from the Cambridge dewpoint hygrometer.

The dynamic pressure probes were calibrated against standard pressures using a servo-controlled system.

The above calibrations were performed both before and after the program. Routine checks on the instruments were also made before each flight.

Location and Type of Data Available

All data collected during the flight missions were recorded on magnetic tapes. They have been reduced and processed by NCAR and will reside at the Illinois State Water Survey. They are available to RAPS researchers, subject to the ISWS data policy. Further information may be obtained from the Principal Investigator.

Publication

Ackerman, B. Vertical Fluxes and Exchange Coefficients in the Air Over St. Louis - Field Program 1975. Illinois State Water Survey, Urbana, Illinois. EPA Grant R803682. February 1977. EPA-600/2-77-027.

6.2.3.2 NCAR BOUNDARY LAYER PROFILERS

Principal Investigator	Project Officer
Bernice Ackerman Atmospheric Sciences Section Illinois State Water Survey Urbana, IL 61901 (217) 333-2210	James L. McElroy Environmental Protection Agency Environmental Monitoring and Support Laboratory Las Vegas, NV 89114 (702) 736-2969

Funding EPA Grant No. R803682

Period of Performance February 1975 to December 1976

Technical Approach

Two tethered-balloon systems for measuring detailed profiles up to a nominal operational altitude of 750 m were loaned to the Illinois State Water Survey for the July field effort by the Field Observing Facility of NCAR. The urban profiler was located in downtown St. Louis, and the rural profiler at Triad High School on Highway 40 about 2.5 km west of Illinois Highway 4.

Basically, the system consisted of a relatively small plastic balloon (inflated volume about 3.25 m^3) with an aerodynamic shape from which was suspended the sensor package. The balloon was tethered to the surface and was raised and lowered using an electric winch. The sensor package provided measurements of air pressure, dry and wet bulb temperature, wind speed and wind direction.

The maximum height actually reached by the profiler depended on the stability and wind speed, decreasing with increasing stability and wind speed. The balloon was let out at 46 m/min and brought back to the surface at nearly twice that rate. The equipment could not be operated under strongly turbulent conditions or in wind speeds of greater than 10 m/sec. Of the 228 soundings that were made in July 1975, nearly 20 are unusable because of instrument malfunction. The remaining 208 soundings appear to be good.

Parameters Measured	Instrument/Method Used
Air pressure	Sealed aneroid capsule
Air temperature	Ventilated bead thermister in radiation shield
Wet-bulb temperature	Wick-covered thermister, mounted 2 cm behind dry temperature sensor
Wind speed	Three-cup anemometer (min. speed: 0.5 m/sec)
Wind direction	Magnetic compass (based on assumption that balloon is effective vane)

The sensors on the boundary layer profiler were interrogated via radio telemetry and recorded in sequence over a 20-second interval during the field operations.

Calibration and Quality Control Procedures

The air pressure sensor, a sealed aneroid capsule, was calibrated over the air pressure range of 900-1000 mb in a computer-controlled Tenney environmental chamber. The cup anemometer was calibrated in the NCAR research wind tunnel over the wind speed range of 0 - 10 m/sec. These calibrations were performed before the field program.

The thermistors used on the tethered balloon were factory calibrated at the Yellow Springs Instrument Company in Ohio. They were tested to be thermally linear within 0.1° C over a span of 25° C, and were checked against an Aspen psychrometer during the field program.

Location and Type of Data Available

Ten parameters were recorded in each record covering twenty seconds, in the following order: high reference, low reference, temperature, wet bulb, pressure, wind speed, temperature, wet bulb, wind speed, wind direction.

These records have been digitized using a digitizer (the Autotrol) which produces punched IBM cards. All of the usable profiler data have been processed and converted into physical parameters: height (using the hypsometric equation), vapor pressure, mixing ratio, dewpoint, relative humidity, saturation vapor pressures at both dry and wet bulb temperatures, virtual temperature, potential temperature, and potential wet bulb temperature. The data are archived on 9-track-1600 BPI magnetic tapes in IBM unformatted binary code. They will reside at the Illinois State Water Survey and are available to RAPS researchers, subject to the ISWS data policy. Further information may be obtained from the Principal Investigator.

Publication

Ackerman, B. Vertical Fluxes and Exchange Coefficients in the Air Over St. Louis - Field Program 1975. Illinois State Water Survey, Urbana, Illinois. EPA Grant R803682. February 1977. EPA-600/2-77-027.

6.2.3.3 USAF MOBILE PIBAL SUPPORT

Principal Investigator	Project Officer
Bernice Ackerman Atmospheric Sciences Section Illinois State Water Survey Urbana, Il 61801 (217) 333-2210	James L. McElroy Environmental Protection Agency Environmental Monitoring and Support Laboratory Las Vegas, NV 89114 (702) 736-2969

Funding EPA Grant No. R803682

Period of Performance February 1975 - December 1976

Technical Approach

Pilot balloons with double-theodolites were used to make wind measurements up to about 2000 m from twelve specified sites scattered in and around St. Louis.

When establishing each site, the survey team selected two suitable spots for the theodolite "pads", requiring that the two be line-of-sight. They then measured off the straight line distance between the two with transit and tape and the difference in elevation with a stadia rod. The orientation of the baseline relative to true north was determined later from sightings on Polaris on clear nights.

Two observers, one at each theodolite, were linked by a land telephone line for communication. Into this line were hooked a tape recorder and a tone generator that was activated by a timer. At the start of the tone, which was set at 20-second intervals and sounded for roughly 3 seconds, the observers centered the balloon on the cross-hairs of the theodolite and kept it there until the tone ended. Then they would read the azimuth and elevation angles of the balloon into their head phones for recording on a cassette tape.

During the field operations, a number of pre-selected pibal sites were activated depending on the missions and balloons were launched at regular time intervals.

Parameters Measured	Instrument/Method Used
Wind speed and wind direction	Observations were made using the double theodolite method with 30-gram balloons. Wind direction and wind speed were calculated using the Thyer method with constant time intervals of 20 seconds.

Periods of Data Collection

February 17-28, 1975
July 1-31, 1975

Pilot balloons were launched at 20-min intervals except for the flux cross section observations during which 10-min launch intervals were used. Sightings to the balloons were recorded at 20-second intervals during the first 13 minutes of each 20-min launch interval.

Calibration and Quality Control Procedures

The theodolites were checked and adjusted by skilled technicians before the program and also by the trained observers on a daily basis throughout the field program. Errors due to misalignment were minimized by having the observers record their shift from short to long scope and by application of the Thyer computational method.

The theodolites were carefully leveled by the observers at the beginning of each experiment. The level was checked periodically during the observational period. Azimuthal orientation in the fixed cartesian coordinate system was accomplished by lining up on the marker at the opposite end of the baseline and on two other marked landmarks off the baseline which had been established when the site was surveyed. The theodolite was azimuthally-oriented at the beginning of each experiment and checked for azimuth to at least one of the markers once or twice during each experiment.

Vertical profiles of errors in wind speed, wind direction, balloon rise rate and height were determined on the bases of three separate field tests

(August 1 and August 9, 1972, and July 31, 1975). The principal conclusion was that the estimated errors were much smaller than the temporal variabilities in the corresponding measurements.

Location and Type of Data Available

The pilot balloon data have been archived on 9-track-1600 BPI magnetic tapes in IBM unformatted binary code. They will be edited by the ISWS and made available to researchers through the RAPS Data Bank. Further information may be obtained from the Principal Investigator.

Publication

Ackerman, B. Vertical Fluxes and Exchange Coefficients in the Air Over St. Louis - Field Program 1975. Illinois State Water Survey, Urbana, Illinois. EPA Grant R803682. February 1977. EPA-600/2-77-027.

6.2.4 BOUNDARY LAYER VARIABILITY STUDY

Introduction

As part of the study of the urban land use and its influence on the overriding air, the University of Wyoming carried out measurements of turbulent fluxes of heat, humidity and momentum as well as incoming and reflected solar radiation flux densities in the St. Louis urban-rural atmosphere during summer 1976. The major instrumented research platform was the NCAR Queen Air 304D.

A complete analysis of the energetics and humidity budget requires other meteorological measurements such as wind shear and temperature profiles that were obtained in separate field programs that are described in Section 6.1.3.

The following discussion will concentrate on the airborne measurements of radiation and turbulent fluxes by the University of Wyoming group during the 1976 summer intensive study period of RAPS.

Principal Investigators	Project Officer
Frank D. Eaton John M. White Department of Atmospheric Science University of Wyoming Laramie, WY 82071	Jason K. S. Ching (MD-80) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711
(307) 766-3245	(919) 541-4524

Funding EPA Grant No. R800875

Period of Performance June 1971 - November 1977

Technical Approach

The instrumented aircraft was flown both alongwind and crosswind over the St. Louis urban-rural complex at various times throughout the day. Typically, the length of each flight leg was approximately 30 km, at altitudes of 150 m, 900 m and 1420 m over the same ground track. The middle and highest elevations would be respectively below and above the typical early afternoon inversion over St. Louis in August. In this way it was feasible to measure the turbulent fluxes both within and above the mixed planetary boundary layer.

Period of Data Collection

Each airborne observation period lasted between one and several hours, depending on the missions, during which both the turbulence and radiation data were recorded continuously.

Parameters Measured	Instrument/Method Used
Air temperature fluctuation	NCAR "K-probe", platinum resistance thermometer
Atmospheric refractive index	NCAR microwave refractometer
Altitude	Static pressure probe (transducer)
Altitude (less than 1 km only)	Radio altimeter
Airspeed	Wing-mounted Rosemount pitot Boom-mounted pitot and transducer
Wind velocity fluctuations and orientation to airstream	Angle of attack, fixed vane Angle of attack, rotating vane Sideslip angle, fixed vane
Boom accelerations	Vertical and lateral accelerometers (boom-mounted)
Aircraft velocity relative to ground; INS-computed latitude and longitude	Inertial Navigational System (INS)
Global solar radiation flux density	Eppley spectral precision pyranometer (pointed upward)
Reflected solar radiation flux density	Eppley spectral precision pyranometer (pointed downward)
Terrestial radiation flux density	Barnes PRT-5 infrared radiometer
Land use patterns	Downward-viewing movie camera (16 mm film)

Calibration and Quality Control Procedures

Calibration of the aircraft instrumentation was conducted by NCAR both before and after the field project.

The main wind instruments in the study were the boom-mounted fixed vanes and the rotating vane used as an alternative. These provided the fluctuating wind velocity components required for calculating the fluxes. They were calibrated using a strain gauge bridge circuit. Bench tests were performed in which calibrated weights were correlated to the output voltages. The vanes were also tested in the Air Force Academy wind tunnel facility at Colorado Springs.

Verification of the NCAR resistance thermometer was done with fixed resistors. The dynamic heating effects were determined by flying the aircraft at different controlled speeds.

Sensitivity calibration for the refractometer (humidity fluctuation) was provided by NOAA. Its offset was further determined from the Cambridge dewpoint hygrometer.

The dynamic pressure probes were calibrated against standard pressures using a servo-controlled system.

The pyranometers were compared against each other and also calibrated against an Ångström pyrheliometer.

Location and Type of Data Available

The turbulence data were recorded at the rate of 16 per second on magnetic tapes. The radiation data have been processed by NCAR into one-second average values on microfilms. These data are available to researchers through the RAPS data bank. For more information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Eaton, F. D., and R. A. Dirks. Turbulent Flux Measurements in the Urban-rural Atmosphere of Greater St. Louis. Paper presented at the Sixth Conference on Inadvertent and Planned Weather Modification, Champaign-Urbana, Illinois. October 1977.

Auer, A. H. Jr., and J. M. White. Inadvertent Weather Modification by Urban Pollution - Final Report. University of Wyoming, Laramie, Wyoming. EPA Grant R800875. November 1977.

White, J. M., F. D. Eaton, and A. H. Auer, Jr. The Net Radiation Budget of the St. Louis Metropolitan Area. Journal of Applied Meteorology, (6):593-599, 1978.

6.2.5 URBAN-RURAL SURFACE ENERGETIC CHARACTERISTICS

Principal Investigators	Project Officer
Walter F. Dabberdt Paul A. Davis SRI International 333 Ravenswood Avenue Menlo Park, CA 94025 (415) 326-6200	James L. McElroy Environmental Protection Agency Environmental Monitoring and Support Laboratory Las Vegas, NV 89114 (702) 736-2969

Funding EPA Contract 68-02-1015

Period of Performance July 1972 - April 1973

Technical Approach

The role of surface geophysical characteristics in the partioning of energy at the complex and heterogeneous metropolitan earth-air interface was evaluated through a unique application of Lettau's climatonomy theory. This methodology permits the determination of the surface descriptors on the basis of the observed diurnal response of the surface to the observed forcing function of available solar energy. Features of various land use types can then be evaluated in the context of the surface energy budget.

During two designated experimental periods, totalling some 50 hours, aircraft data-collection missions were flown repetitively at 2-3 hour intervals along a selected flight track across the St. Louis area. The aircraft used during this experiment was an Aerocommander owned by Colorado State University. The airborne measurements were supplemented by a pyranometer/radiometer site established at the Granite City Army Depot (August 1972) and at St. Louis University (April 1973).

Periods of Data Collection

August 9-12, 1972
April 17-27, 1973

Parameters Measured	Instrument/Method Used
Total Downwelling Solar Irradiance	Eppley pyranometer
Total Upwelling Solar Irradiance	Yellott SOL-A- METER (solarimeter)
Surface Temperature (remote)	Barnes PRT-5 radiometer
Wet and Dry Bulb Temperatures	Model unknown
Subtrack Photographs	Hasselblad 70 mm camera
Total Solar Irradiance	Eppley precision spectral pyranometer
Incident Radiation	Eppley pyrgeometer infrared radiometer
	C.S.I.R.O. net radiometer

Calibration and Quality Control Procedures

All of the radiation sensors were calibrated and tested prior to and following each of the two field experiments.

Location and Type of Data Available

The experimental data are contained in graphical and tabular form in the report cited below. Additional information may be obtained from the EPA Project Officer.

Publication

Dabberdt, W. F., and P. A. Davis. Determination of Energetic Characteristics of Urban-Rural Surfaces in the Greater St. Louis Area. Stanford Research Institute, Menlo Park, California. EPA Contract 68-02-1015. April 1974. EPA-650/4-74-007.

7.0 POLLUTANT TRANSFORMATION AND REMOVAL STUDIES

Introduction

The formation rate and mechanism of particulate sulfur compounds in the atmosphere is recognized as an important problem in current environmental research. Hence, the focus of the pollutant transformation and removal studies was on oxides of sulfur, with much of the experimental work devoted to the dynamics of aerosol formation. The experiments described in Section 7.0 may be divided into four areas of emphasis.

In the point source component of this study, oxides of nitrogen, oxides of sulfur, and ozone, together with the spectrum of aerosol size, were sampled at increasing travel times from the sources to determine transformations occurring within relatively high pollutant concentrations. Similar studies were conducted of the complete mix of pollutants in the plume from the entire urban complex.

Photochemical reaction studies were performed to ascertain the photochemically stimulated transformations in order to develop appropriate chemical kinetic models.

Aerosols were sampled in an effort to characterize them in terms of their physical and chemical properties and their probable origins and evolution.

Under pollutant removal experiments, studies of dry removal processes were conducted to determine the dry deposition rate for SO_2 as a function of different land classes. Precipitation scavenging was also studied.

7.1 POINT SOURCE AND URBAN PLUME STUDIES

7.1.1 PLUME MAPPING PROGRAM (MISTT)

7.1.1.1 WASHINGTON UNIVERSITY

Principal Investigator	Project Officer
Rudolph B. Husar Air Pollution Research Laboratory Mechanical Engineering Department Washington University St. Louis, MO 63130	William E. Wilson (MD-84) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711
(314) 889-6099	(919) 541-2551

Funding EPA Grant Nos. R802815 and R803896

Periods of Performance

EPA Grant No. R802815	November 1973 - December 1977
EPA Grant No. R803896	April 1975 - March 1978

Technical Approach

Washington University provided field direction for the 1974, 1975 and 1976 field experiments of the Midwest Interstate Sulfur Transport and Transformation (MISTT) study, a program closely allied with and partially funded by RAPS. Washington University also provided near real-time data processing of MISTT measurements and participated actively in subsequent MISTT data analyses. The University's Air Pollution Research Laboratory (APRL) performed chemical analyses of various filter sampler collections.

Washington University furnished a scout/communications relay aircraft during the 1975 and 1976 MISTT experiments and an instrumented Aerocommander during the 1976 field experiment. The scout aircraft was lightly equipped to enable the vectoring of other more completely instrumented aircraft into the plumes at long distances downwind. Because of these distances, the scout aircraft was also utilized to relay communications and data between the aircraft and the mission control facility at Washington University. During the 1976 MISTT experiment, a second scout aircraft equipped with a correlation spectrometer was operated by Environmental Measurements, Inc. under contract to Washington University (Section 7.1.1.3).

Along with the Cessna 206 provided by Meteorology Research, Inc. (Section 7.1.1.2), the instrumented Aerocommander was an integral part of the MISTT field program which consisted of airborne sampling platforms and associated ground support. The purpose of the Aerocommander flights was to locate and track the plumes originating from the Labadie Power Plant (about 60 km west of St. Louis) as well as from the St. Louis urban-industrial complex, and to document the pollutant burdens as a function of time and distance from the sources.

The flight patterns of the aircraft were designed for detailed characterization of the plume at discrete distances downwind of the source. At each distance, horizontal traverses were made in the plume perpendicular to the plume axis at three or more elevations. The traverses were augmented by vertical spirals outside the plume and near the plume centerline, extending up to at least 100 meters above the mixing layer height or the maximum plume height. The plume mapping began near the source and proceeded downwind, with the two sampling aircraft making measurements, whenever feasible, following a single air parcel. In some instances, the two aircraft performed a coordinated parallel traverse for data comparison. Based on the weather forecast, several plume mapping scenarios were elaborated at least 12 hours in advance of each sampling mission at a planning meeting. A typical sampling mission consisted of two or three sampling flights, each lasting 2 - 4 hours. The premission pibal data were used as the final input in making the decision to implement a specific flight plan for the mission.

Periods of Data Collection

July 29 - August 16, 1974	MRI Cessna
July 14 - August 15, 1975	MRI Cessna, Scout Aircraft
June 27 - August 3, 1976	MRI Cessna, WU Aerocommander, Scout Aircraft

Parameters Measured (Aerocommander)	Instrument/Method Used
Light Scattering Coefficient (b_{scat})	Meteorology Research, Inc. (MRI) Model 1550 integrating nephelometer. Sensitivity range of 10^{-5} to 10^{-2} reciprocal meters.
Aerosol Concentration	Environment/One Condensation Nuclei Counter (CNC) responding to particles especially in the 0.01 to 0.1 µm size range.
Aerosol Charge Detector	Washington University developed aerosol charge detector using an ionizer/electrometer analysis technique. Measurement range was 0.01 - 1.0 µm with a 3 second response time.
Particulates	Filter samples were collected by a two-stage filter-tape sampler that collects separate deposits for coarse (>3µm) and fine (<3µm) particles.
Total Sulfur	Meloy SA-285 flame photometric sulfur analyzer with a lower detection limit of 0.5 ppb and high temperature stability.
Ozone	Dasibi UV-absorption instrument.

The above instruments were interfaced to a Metrodata Model DL640 data logger and simultaneously recorded on a four channel strip chart recorder and digital cassette recorder. The data logger recorded signals from the instruments every 2 seconds. Standard aircraft positioning instruments were also interfaced to the data logger.

Calibration and Quality Control Procedures (Aerocommander)

Before each mission, the calibrations of SO_2 and O_3 instruments was performed by EPA using standard calibration gases. During the flights, these instruments, as well as the aerosol instruments, were zero-checked at frequent intervals. At the end of each mission, the instrumentation in the aircraft underwent detailed, multipoint calibration. Between missions, the instruments were operated by external power provided in the base hanger.

Graphical outputs of the aircraft data were generated within hours of each field mission. These computer plots were inspected to check for any indications of instrument malfunctions or any other abnormalities. The results of data processing and preliminary analyses were presented at a review meeting on the day following the sampling mission. These meetings were attended by the pilots, instrument operator/observers, data processing personnel, the field manager and other participants of the program. The flight pattern, the meteorology and the data were reviewed in order to identify the weak points and suggest possible improvements in the sampling program.

Location and Type of Data Available

The data are in the custody of the Principal Investigator to whom all inquiries may be directed. The data are available on magnetic tapes as well as in the form of a hard copy volume of data plots.

Publications

Gillani, N. V., R. B. Husar, and D.E. Patterson. 1976 Washington University Aircraft Data Volume. Washington University, St. Louis, Missouri. December 1976.

Wilson, W. E., R. J. Charlson, R. B. Husar, K. T. Whitby, and D. L. Blumenthal. Sulfates in the Atmosphere - A Progress Report on Project MISTT. Environmental Sciences Research Laboratory, Research Triangle Park, North Carolina. March 1977. EPA-600/7-77-021.

Husar, R. B., D. E. Patterson, J. D. Husar, N. V. Gillani, and W. E. Wilson. Sulfur Budget of a Power Plant Plume. Atmospheric Environment, 12:549-568, 1978.

Gillani, N. V., R. B. Husar, J. D. Husar, D. E. Patterson, and W. E. Wilson. Project MISTT: Kinetics of Particulate Sulfur Formation in a Power Plant Plume out to 300 Km. Atmospheric Environment, 12:589-598, 1978.

7.1.1.2 METEOROLOGY RESEARCH INSTRUMENTED CESSNA

Principal Investigator	Project Officer
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Funding

EPA Contract No. 68-02-1081, Task Order No. 41
EPA Contract Nos. 68-02-1919, 68-02-2245, 68-02-2411

Periods of Performance

Task Order No. 41	July - August 1974
EPA Contracts	June 1974 - June 1977

Technical Approach

As part of Project MISTT, airborne measurements of the physical and chemical characteristics of urban and power plant plumes were performed to determine plume transport and dispersion properties. One of the primary sampling platforms used for the project was an instrumented Cessna 206 provided and operated by Meteorology Research, Inc. (MRI). In contrast to previous demonstration versions of this airborne sampling platform (Section 7.3.1.2), the following paragraphs describe this aircraft's equipment and how it was used in conjuction with several investigators' experiments during the project.

Periods of Data Collection

July 29 - August 16, 1974
July 14 - August 15, 1975
June 27 - August 3, 1976

Parameter Measured	Instrument/Method Used
Sulfur Dioxide	Theta Sensors L5400 sulfur dioxide analyzer using an electro-chemical cell technique. The typical measurement range was 0-1.0 ppm with a response time of 9-15 seconds with an approximate resolution of 0.01 ppm.
Nitric Oxide/Oxides of Nitrogen	Monitor Labs 8440 chemiluminescent analyzer with a typical measurement range of 0-0.5 ppm. Response time was 9-10 seconds and approximate resolution was 0.01 ppm.
Ozone	REM 612 chemiluminescent ozone monitor usually set on the 0-0.5 ppm range. Response time was 5 seconds and the approximate resultion was 0.005 ppm.
Hydrocarbons/Halocarbons	Stainless steel canisters pressurized to 1 atm by a Metal Bellows MB-158 pump were used to save air samples for subsequent gas chromatography analyses.
Sulfates	MRI Two-Mass (prototype) flash vaporization/flame photometric detector measuring sulfate particles less than 3 μm in diameter. Response time was 10 minutes with an approximate resolution of 3 μgm^{-3}.
Aerosol Composition	MRI Airborne Impactor System with 3 stages and filters. Samples were analyzed by microscopy and IEXE techniques.
Light Scattering Coefficient	MRI 1550 Integrating Nephelometer with a measurement range of 0.1 to 10 x $10^{-4}m^{-1}$. Response time was 1 second

Parameter Measured	Instrument/Method Used (continued)
	with an approximate resolution of $0.1 \times 10^{-4} m^{-1}$.
Aerosol Charge Acceptance	This instrument was constructed by Washington University and used an ionizer/electrometer analysis technique. Measurement range was 0.01 - 1.0 μm with a 3 second response time.
Condensation Nuclei	Environment/One Rich 100 condensation nuclei counter with 3 second response time.
Aerosol Size Distribution	Thermo Systems Inc. Model 3030 electrical aerosol analyzer sensing particles in the 0.006 - 1.0 μm range. A Royco Model 218 optical particle counter was also used. There was a 3 minute analysis time per distribution.
Turbulence	Meteorology Research, Inc. Model 1120 sensing pressure fluctuations with a range of 0 - 10 $cm^{2/3}s^{-1}$. Response time was 3 seconds to 60%.
Temperature	A Yellow Springs Instruments bead thermistor housed in a Meteorology Research, Inc. Vortex housing. Range was from -5° to +45°C. Response time was 5 seconds.
Dew Point	Cambridge Systems Model 137 cooled mirror dew point sensor with a range of -50° to +50°C. Response time was 0.5 seconds per degree C with 0.5°C resolution.

Parameter Measured	Instrument/Method Used (continued)
Altitude and Indicated Airspeed	Validyne absolute and differential pressure transducers with respective ranges of 0 - 3,000 meters MSL and 20 to 65 meters per second. Response time was 1 second and accuracy was 6 meters and 0.1 meters per second, respectively.
Position	King KX170B/Metrodata M8 Aircraft VOR/DME with a range of 0-75 km from the station. Response time was 1 second and resolution was 1° bearing and .2 km distance.

The above equipment was interfaced to a Metrodata 620 data logger which had an input range from 0 to 9.99 volts DC with 0.01 volts DC resolution. Scan rate was 0.8 seconds per 40 channel scan. A Linear Instruments dual channel strip chart recorder was also used. Power was supplied by a 1000 VA Topaz inverter.

Air samples were brought in through three 4.1 cm and one 0.9 cm ID inlet tubes mounted on a dummy window. An additional 0.3 cm ID inlet tube was used for the hydrocarbon/halocarbon sample collection system.

Calibration and Quality Control Procedures

Preparation of the aircraft for a sampling mission began about 2.5 hours before takeoff with a visual inspection of the instruments, as well as sample lines, electrical connections, and external sensors. The instruments were then turned on and allowed to warm up for about 1.5 hours. After the warm up period, a detailed checklist was used to prepare the system for sampling. This checklist covered items such as range switch settings, flow rates, internal calibration and zero checks, grab sampling and data acquisition system checks, and preparation of flight record sheets. A standard form was filled out during pre-flight preparation to document the status of instruments prior to the mission.

Immediately after takeoff, those instruments which could not be completely prepared on the ground were checked for proper operation (e.g., those instruments that used the venturi exhausts for vacuum). Frequent scans of all data channels on the data logger were made by the instrument operator to ensure prompt detection of instrument malfunctions.

The calibration system for the calibrations of the continuous gas analyzers in 1976 was based on a Bendix 8861 calibrator, modified to include mass flow controllers. This system provided NO calibration gas using gas phase dilution of a 100 ppm reference gas bottle, and NO_2 and O_3 using gas phase titration techniques. Sulfur dioxide calibrations were performed using a permeation tube operated in a temperature-controlled water bath. Critical parts of the calibration system (e.g., flow controllers, NO span gas) were checked before and after the field program to verify their stability. The EPA-supplied calibration systems used in 1974 and 1975 were similar in nature, and were operated by EPA personnel.

In general, the continuous gas analyzers were calibrated immediately after each sampling mission. Each calibration consisted of a zero reference plus 2-5 upscale readings. Equilibration times between readings ranged from about 2 min (SO_2) to 10 min (NO/NO_x, O_3); a strip chart recorder was used to determine when the steady-state value had been reached. Calibration gas concentrations were chosen to reflect the range of concentrations encountered on sampling missions (SO_2: 0.15-2.4 ppm, NO: 0.04-0.5 ppm, O_3: 0.02-0.3 ppm). The efficiency of the NO_x converter in the NO/NO_x analyzer was checked during each calibration.

The aerosol size distribution measurement system, condensation nuclei monitor, and aerosol charge acceptance monitor were calibrated by the University of Minnesota before the field program using the monodisperse aerosol generation techniques described by Marple (1974). Calibrations of the integrating nephelometer were performed by MRI before and after the field program, using Freon-12 as the reference gas. Span and zero checks of the nephelometer using its internal calibrator were performed as part of the routine pre-flight procedures. The technique used to calibrate the sulfate analysis system was developed by R. Husar.

Location and Type of Data Available

Initial processing of the aircraft data was performed at Washington University and the preliminary results were used to guide further sampling missions. This processing involved copying the Metrodata cartridges to a 1/2-inch magnetic tape and producing plots of important parameters as a function of time. Final processing was performed at MRI and other laboratories (see sections 7.1.1.1 and 7.1.1.5) involved in the project, and included application of zero drift and calibration corrections to the data. The outputs of the final data processing step were 1/2-inch magnetic data tapes, as well as plots of parameters measured by the aircraft for each sampling run.

For information on data availability, contact the Project Officer.

Publications

Jones, A. C. Aircraft Monitoring Support for Characterization Study in the St. Louis Area. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 41 Final Report, EPA Contract 68-02-1081. October 1974.

Smith, T. B., D. L. Blumenthal, J. A. Anderson, and A. H. Vanderpol. Transport of SO_2 in Power Plant Plumes: Day and Night. Atmospheric Environment, 12:605-611, 1978.

Blumenthal D. L., J. A. Ogren, and J. A. Anderson. Airborne Sampling System for Plume Monitoring. Atmospheric Environment, 12:613-620, 1978.

7.1.1.3 ENVIRONMENTAL MEASUREMENTS MOBILE VAN

Principal Investigator	Project Officers
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Funding

EPA Contract No. 68-02-1851
EPA Grant No. R803896 (through Washington University)

Periods of Performance

EPA Contract No. 68-02-1851	July 1974 - February 1975
EPA Grant No. R803896	July 1975 - August 1976

Technical Approach

The EMI instrumented van was equipped with various monitoring arrays to meet the requirements of the MISTT program. This was to track point source and urban plumes in the St. Louis area at the surface level and aloft, and to observe changes in plume chemistry and composition. The van was also utilized near other monitoring installations for measurement comparisons and variability studies (Section 8.3.1.2). EMI participation in the 1976 Summer MISTT experiment only entailed operating a correlation spectrometer on board a scout aircraft. A summary of the van monitoring instruments and their periods of operation in the other MISTT experiments are included in Table 10.

TABLE 10. EMI INSTRUMENTED VAN OPERATIONAL PERIODS AND EQUIPMENT

STUDY PERIOD	MISTT 1974 29 July - 4 August 1974	MISTT 1975 18 July - 12 August 1975	MISTT 1976 3 March - 13 March 1976
Barringer Correlation Spectrometer	X	X	X
Meloy SA-185 Total Sulfur Analyzer	X	X	X
TECO 14-B NO/NO_X Monitor	-	X	-
MRI 1550 Integrating Nephelometer	-	X	X
WU/APRL Aerosol Charger	-	X	X
WU/APRL TWO MASS Tape Sampler	-	X	X
Dasibi 1003 AAS Ozone Analyzer	-	-	X
EMI Mobile Automated Plotter	-	X	X

Periods of Data Collection

The actual data collection periods are shown in Table 10. The EMI mobile automated plotter (MAP) records the van's position once every six or eight seconds. When the position is recorded the data channels are scanned, recorded and printed by the line printer in the van. The data are recorded digitally on a HECON A0737 cassette recorder. A six pen Rikandenki chart recorder provides a backup system and a real time analog display. Prior to the use of the MAP unit the Rikandenki chart recorder was coupled with a precision odometer which varied the recorder speed proportional to the van speed. By manually marking the chart record when locations with known UTM coordinates were passed exact locations could be interpolated which corresponded with pollutant anomalies.

Parameters Measured	Instrument/Method Used
Total Overhead Nitrogen Dioxide and Sulfur Dioxide Burden	Barringer COSPEC III correlation spectrometer indicating ppmm to the nearest ± 10 ppmm.
Total Sulfur	Meloy SA-185 flame photometric total sulfur monitor. Range varied somewhat but was normally 0.00-0.50 ppm. Concentrations read to nearest 0.01 ppm.
Surface Oxides of Nitrogen Concentrations	Thermo Electron Corporation 14-B chemiluminescent monitor, 0.00-0.50 ppm range. Concentrations read to nearest 0.01 ppm.
Surface Back Scattering Coefficient	MRI model 1550 integrating Nephelometer equipped with Air Pollution Research Laboratory (APRL) at Washington University designed heater to facilitate study of volatile aerosol species.
Sub-micron Aerosol Concentrations	APRL Aerosol Charger counting sub-micron particles with high surface area.

Parameters Measured	Instrument/Method Used (continued)
Fine Particulate Sulfate Analysis	APRL TWO MASS tape sampler collecting spots for fine particulates (sub 3.5 microns). When advanced, exact time and location was annotated by the EMI navigational system. The sulfur determination was carried out by the flash vaporization-flame photometric detection technique in the APRL Laboratories at Washington University.
Surface Ozone Concentrations	Dasibi 1003 AAS ultraviolet absorbtion ozone analyzer, 0.00 to 0.25 ppm range. Concentration read to the nearest 0.01.
Location and Data Recording	EMT Mobile Actomated Plotter. The navigational system includes direction, distance and time sensors. The bearing with respect to true North and distance traveled are fed into a Hewlett-Packard 9830 programmable calculator which computes UTM coordinates in real time. The position is updated every 6 or 8 seconds. Data are recorded on a HECON system. The cassettes were delivered to APRL at Washington University for logging and analysis at the central computer complex. A six pen Rikadenki chart recorder provides a real time analog display and backup system.

Electrical power was provided by a 4 kw ONAN generator installed in the rear of the van. All gaseous and aerosol samples were ducted through a common Teflon and glass manifold to their respective analyzers.

Calibration and Quality Control Procedures

Barringer Correlation Spectrometer	Internal calibration cells containing known quanities of SO_2 and NO_2 were rotated into the optical path, the voltage output changed in proportion to the pollutant concentrations. This instrument was equipped with calibration cells having concentrations of 75 ppmm and 180 ppmm for SO_2 and 38 ppmm and 115 ppmm for NO_2. The magnitude of the changes during calibration were determined from the line printer display during calibration. This assures that and filtering due to recording on magnetic tape would be taken into account during calibration procedures.
Meloy SA-185 Sulfur Monitor	Calibration was performed daily using a Metronics Dynacalibrator system coupled with an NBS traceable permeation tube. Tube was maintained at a constant 25°C and the flow rate at 200 cc/min. Calibration was performed daily.
TECO 14B Nitrogen Dioxide Monitor	Calibrated by EPA using a pressure bottle of known NO content which is diluted with clean air in a Bendix dilution system to achieve a range of concentrations. Usually calibrated once per study period.
MRI 1550 Integrating Nephelometer	Nephelometer was calibrated before and after each study using Freon 12.

Location and Type of Data Available

Additional information as well as the data collected are available on magnetic tape from the Principal Investigator.

Publications

Sperling, R. B., and W. M. Vaughan. Limited SO_2 and NO_x Measurements in St. Louis, 1974: Volume I - Plume Tracking by Correlation Spectroscopy. Environmental Measurements, Inc., San Francisco, California. EPA Contract 68-02-1851. February 1975. EPA-650/2-75/005-a.

Vaughan, W. M. Moving Laboratory Field Measurements Executed by Environmental Measurements, Inc. for the Midwest Interstate Sulfur Transport and Transformation Study. Environmental Measurements, Inc., University City, Missouri. Subcontractor Report for EPA Grant R 803896. January 1976.

7.1.1.4 MOBILE PIBAL SUPPORT

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Funding

EPA Contract No. 68-02-1081, Task Order Nos. 41 and 61
EPA Contract No. 68-02-2093, Task Order Nos. 111 and 115

Periods of Performance

Task Order No. 41 - August 1974
Task Order No. 61 - July - August 1975
Task Order No. 111 - March 1976
Task Order No. 115 - June - July 1976

Technical Approach

One objective of the MISTT Plume Mapping Program was to mathematically describe the nature and role of pollutant transformation and removal processes downwind of urban sources. Various phases of this program were undertaken to study the rate processes acting on aerosols and aerosol precursor gases in urban plumes and in tall stack plumes from local power generating stations. In order to derive the rate processes from aircraft plume measurements, it was necessary to know the effective transport mechanism. Mobile pilot balloon (pibal) observations were utilized to obtain wind data for derivation of the transport wind profile over the St. Louis Metropolitan Area and surrounding areas of Missouri, Illinois, Iowa, Indiana, and Kentucky.

Periods of Data Collection

Actual mobile pibal data collection dates were as follows:

Task Order No. 41 - August 3 - 15, 1974
Task Order No. 61 - July 17 - August 13, 1975
Task Order No. 111 - March 2 - 12, 1976
Task Order No. 115 - June 29 - July 30, 1976

During operational periods, pibal observations were made at one-half hour intervals.

Parameters Measured	Instrument/Method Used
Wind Speed and Wind Direction	10 or 30 gram pilot balloon (pibal) observations using the single theodolite method. Calculated wind speed and wind direction from angular values observed at a constant time interval of 30 seconds.

Calibration and Quality Control Procedures

Except for the minimum observation being five minutes (weather permitting), all pibals were released in accordance with Upper Air Sounding Network procedures (Section 4.0). Because mobile pibal site orientation points have to be determined, a compass with sighting apparatus was used at each site to locate a reference point for Magnetic North. A reference point for True North was established by correction for the appropriate magnetic declination angle, obtained from U. S. Geological Survey maps.

Quality control procedures included reviewing elevation and azimuth angles for angular continuity and checking for correct magnetic declination Theodolites were checked and collimated prior to each study period. Theodolite orientation was checked before and after each pibal release.

Information Concerning Data Collection

Information concerning data collection or any additional information may be obtained by contacting the EPA Task Coordinators.

Location and Type of Data Available

Data are available on magnetic tape as part of the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Jones, A. C. Aircraft Monitoring Support for Characterization Study in the St. Louis Area. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 41 Final Report, EPA Contract 68-02-1081. October 1974.

Bryant, J. D. MISTT Plume Study, Pibal Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 61 Final Report, EPA Contract 68-02-1081, November 1975.

Waldron, T. L. EMI Plume Study, Pibal Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 111 Final Report, EPA Contract 68-02-2093, April 1976.

Waldron, T. L. MISTT Plume Study, Pibal Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 115 Final Report, EPA Contract 68-02-2093, November 1976.

7.1.1.5 UNIVERSITY OF MINNESOTA AEROSOL MEASUREMENTS

Principal Investigator	Project Officer
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Funding EPA Grant No. R803851-02

Period of Performance July 1974 - August 1976

Technical Approach

The principal objectives of the study were: 1) to measure the size distribution of the aerosol particles as a function of plume age, altitude, etc. 2) to determine the aerosol volume growth, and 3) to estimate the rate of nucleation in the plume.

An instrumented Cessna 206 aircraft was used for this study (Section 7.1.1.2). The basic flight pattern used to map the plume (Labadie power plant - St. Louis) consisted of a spiral upwind of the source from 3,000 m to 150 m above ground to obtain a profile of the background concentration. An aerosol sample taken every 305 m provided a fairly good characterization of the vertical background distribution of aerosol in the air that will be mixed with the plume. Next, several sets of horizontal measurement passes were made through the plume approximately at right angles to its direction of movement with the prevailing wind. Each set of passes consisted of a number of flights at a fixed distance downwind of the source passing through the body of the plume at altitudes that increased or decreased by a fixed increment for each pass. These were continued until a representative cross-section of the plume at that distance was mapped. The flight pattern was then repeated at distances further downwind, dictated by the meteorology for that day and the terrain over which the flight occurred. Aerosol samples for size distribution measurements were taken near plume center, one for each pass. The size of the aerosol sample was determined by the speed of the aircraft, the 2.5 min. minimum analysis time required by the aerosol analyzer and the width of the plume. Normally, additional size distribution measurements were made outside the plume during each cross-sectional mapping for background characterization.

At various distances downwind of the source, more vertical spiral patterns were flown. These were usually flown at the position of a cross-sectional mapping near plume center from just above the plume down through it. Such spirals provide vertical concentration profiles and help to establish the vertical extent of the plume. Together with radiosonde and pilot balloon data, the cross-section mapping and vertical spiral results were used to reconstruct a fairly accurate picture of the plume geometry.

Periods of Data Collection

July 29 - August 16, 1974
July 14 - August 15, 1975
June 27 - August 3, 1976

Parameters Measured	Instrument/Method Used
Total Aerosol Concentration	Environment/One condensation nuclei counter (CNC). In the 1974 study a standard instrument was used measuring Aitken nuclei.
Light Scattering Coefficient (b_{scat})	Meteorology Research, Inc. (MRI) Model 1550 integrating nephelometer. Sensitivity range of 10^{-5} to 10^{-2} reciprocal meters.
Particle Size Distribution	Thermo-Systems Model 3030 Electrical Aerosol Analyzer (EAA). The EAAs used

Parameters Measured	Instrument/Method Used (continued)
Particle Size Distribution (continued)	in 1974 and 1975 were limited in their ability to make usable measurements of particles less than 0.02 μm because of a charge buildup problem on the bottom collector rod insulator. A highly modified Royco Model 218 optical particle counter (OPC) was also used. Since the last channel of the EAA was not usable at low concentrations because of the aircraft data acquisition system, the lowest channel of the OPC was set up to measure the 0.56 to 1 μm range. Together the EAA and OPC resolved the aerosol size distribution between 0.006 and 4.5 μm diameter into 11 discrete intervals.

All of the above instrumentation as well as the rest of aerometric equipment aboard the Cessna are described in section 7.1.1.2 and the aerosol instrument descriptions presented here are for additional clarification.

Because of the various requirements of the different aerosol instruments, separate aerosol sample inlets were used, one each for the condensation nuclei counter and integrating nephelometer, sulfur aerosol sampler, and the OPC-EAA combination. Because the latter two instruments are cyclic, requiring a minimum of 2.5 minutes to complete a measurement cycle, it was necessary to obtain a static air sample and store it in a bag (200 liter) for them. In this way, the aerosol measurement was made at one point in the plume and not integrated over the large concentration gradients present. The bag sampling system used in 1974 had a manually operated three-way valve for filling, sampling, and emptying the bag. Fill time was about two seconds, hold time about 2.5 minutes, and emptying time about 10 seconds.

Aerosol losses in such a sampling system were significant for both large and small particles. Therefore, a detailed theoretical calculation of the sampling efficiency as a function of size was made. This included the isokinetic sampling efficiency outside the aircraft, losses in bends and valves, diffusion and turbulent deposition in sampling lines, and settling in the sampling bag. A sampling efficiency curve was used to correct the raw count data from the optical particle counter and electrical aerosol analyzer. However, it is believed that there were enough uncertainties in the calculated efficiencies below 0.01 and above 2 μm that data outside these limits were not used.

Calibration and Quality Control Procedures

The instruments used were calibrated prior to their use. The Environment/One Condensation Nuclei Counter was calibrated at the University of Minnesota before the flight. The MRI Nephelometer was calibrated by MRI prior to the sampling period. The Thermo Systems Aerosol Analyzer was calibrated prior to the flight. An adjustment was made during data reduction since the monodisperse calibration was judged inadequate. The Royco Optical Particle Counter was a highly modified instrument, calibrated at the University of Minnesota.

Location and Type of Data Available

Original data are at the University of Minnesota. Inquiries may be directed to the Principal Investigator.

Publications

Whitby, K. T., B. K. Cantrell, and D. B. Kittelson. Nuclei Formation Rates in a Coal-Fired Power Plant Plume. Atmospheric Environment, 12:313-321, 1978.

Cantrell, B. K., and K. T. Whitby. Aerosol Size Distributions and Aerosol Volume Formation for a Coal-Fired Power Plant Plume. Atmospheric Environment, 12:323-333, 1978.

7.1.1.6 UNIVERSITY OF WASHINGTON MOBILE LABORATORY

Principal Investigator	Project Officer
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Funding EPA Grant No. R800665

Period of Performance April 1971 - December 1974

Technical Approach

The University of Washington operated a mobile laboratory in the St. Louis area from August through October 1973. The purpose of this laboratory was to gather field data in an effort to characterize aerosols, particularly those that affect visibility. Various aerosol scattering parameters in urban and rural locations were measured and optical methods and equipment for identifying background aerosols were demonstrated. The specific method of interest in this study was a light scattering/humidity relation which was used to detect the reaction of ambient aerosols with NH_3 to form the deliquescent salt $(NH_4)_2SO_4$.

Periods of Data Collection

Data was collected from August 20 to October 5, 1973. The exact sampling periods for measurements concerning the light scattering/humidity relationship are shown in Table 11. Other measurements were taken intermittently thoughout the sampling period.

TABLE 11. UNIVERSITY OF WASHINGTON SAMPLING PERIODS

LOCATION	SAMPLING PERIOD	SAMPLING FREQUENCY
Washington University	8/21 - 8/31	Non-NH_3 run every half hour with one NH_3 injection during the entire sampling period.
Tyson	9/3 - 9/21	NH_3 injection run were performed occasionally with non-NH_3 every half hour.
	9/21 - 9/27	NH_3 injection run every hour with non-NH_3 every half hour
St. Louis University	9/27 - 10/4	NH_3 injection run every half hour with a non-NH_3 run preceeding it by 15 minutes.

Parameters Measured	Instrument/Method Used
b_{sp} - Scattering extinction coefficient of particles at 530 nm (Rayleigh coefficient at 530 nm = $0.15 \times 10^{-4}m^{-1}$)	University of Washington patented Integrating Nephelometers measuring b_{sp} in units of $10^{-4}m^{-1}$. These nephelometers were arranged in a special apparatus called a humidograph which allowed for a light scattering /humidity relationship to be measured. A diagram of the apparatus is shown in Figure 6.
αRG - Wavelength exponent (Red - Green)	Wavelength exponent calculated from Red-Green b_{sp} values. Red = 640 nm, Green = 530 nm.
αBG - Wavelength exponent (Blue - Green)	Wavelength exponent calculated from Blue - Green b_{sp} values. Blue = 430 nm, Green = 530 nm.

Parameters Measured	Instrument/Method Used (continued)
Scattering ratio	Scattering ratio calculated from the ratio of half sphere back scatter to b_{sp} from particles at 530 nm.
b_{ap} - Particle absorption extinction coefficient	Measured using the method described by Lin (1973). Atmospheric aerosol was collected by passing ambient air through a Nucleopore filter. The optical absorption coefficient due to particles, b_{ap}, was calculated by passing a known volume of air through the filter during collection of the aerosol.
b_{ext} - Extinction coefficient of a real atmosphere	Obtained by calculating the sum of b_{ap} and b_{sp}.
Absorption fraction of extinction	Calculated as the ratio of b_{ap} to b_{ext}.

$H_2SO_4/(NH_4)_2SO_4$ background aerosol

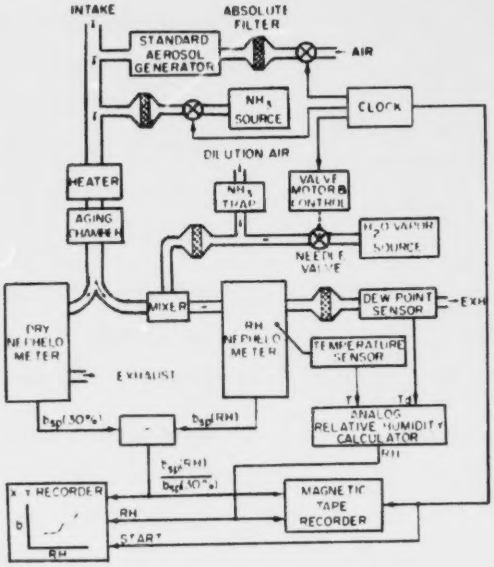

FIGURE 6. HUMIDOGRAPH WITH NH_3 PRETREATMENT

Calibration and Quality Control Procedures

At preselected times during the field measurements (usually midnight) a standard aerosol [ie. H_2SO_4 or $(NH_4)_2SO_4$] was injected into a filtered air stream for the generation of one humidogram, and in the case of H_2SO_4 a second humidogram was generated after the addition of NH_3 in order to check the system response and hygrometer calibration. All dilution air was passed through an NH_3 trap of H_2SO_4 on a fibrous glass filter, and then passed through an absolute filter to assure no effects due to a locally derived aerosol or NH_3. Tests were also run to establish that NH_3 addition did not create new particles but only reacted with existing ones. The data were also examined for increases in b_{sp} due to NH_3 and none was found.

Location and Type of Data Available

Summaries and conclusions based on the collected data are contained in the grant report listed below. For additional information on data availability contact the Principal Investigator.

Publications

Waggoner, A. P., and R. J. Charlson. Aerosol Characteristics and Visibility. University of Washington, Seattle, Washington. Grant Report, Grant R800665. July 1977. EPA-600/3-77-072.

Charlson, R. J., A. H. Vanderpol, D. S. Covert, A. P. Waggoner and N. C. Ahlquist. $H_2SO_4/(NH_4)_2SO_4$ Background Aerosol: Optical Detection in the St. Louis Region. Atmospheric Environment, 8:1257-1267, 1974

Vanderpol, A. H., F. D. Carsey, D. S. Covert, R. J. Charlson, and A. P. Waggoner. Aerosol Chemical Parameters and Air Mass Character in the St. Louis Region. Science, 190:570-578, 1975.

7.1.1.7 ARGONNE NATIONAL LABORATORY ACOUSTIC SOUNDER

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Funding Joint MAP^{3}S and MISTT

Periods of Performance

July - August 1975
July 1976

Technical Approach

The main objective of this experiment was to investigate the evolution of the planetary boundary layer capping inversion between the hours of 0400 and 1200. To do this, hourly radiosonde or pibal ascents were tracked to give wind and temperature profiles. Surface pressure, temperature and humidity measurements were made at Galesburgh, Champaign and Auburn (Illinois). A network of four accoustic sounders measured mesoscale variations near the inversion at Glasgow, Palmyre, Waverly and Auburn. Only the sounder at Glasgow fell within the RAPS study area.

Periods of Data Collection

The acoustic sounder was operational during the following periods:

July 15 - August 15, 1975	0400 to 1200 CST
July 15 - July 30, 1976	1600 to 2400 CST

Parameter Measured	Instrument/Method Used
Acoustic echo returns reflecting turbulent fluctuations of atmospheric temperature	Argonne National Laboratories acoustic sounder with a range of approximately 500 meters.

Location and Type of Data Available

All data are located at Argonne National Laboratory. Further information may be obtained by contacting the Principal Investigator.

Publications

Hess, D. G., and B. B. Hicks. A Study of PBL Structure: The Sangamon Experiment of 1975. Argonne National Laboratory, Argonne, Illinois. Radiological and Environmental Research Division Annual Report, January - December 1975, ANL-75-60, Part IV.

Sisterson, D. L., B. B. Hicks and M. L. Wesely. An Outline of the 1976 Sangamon Field Experiment. Argonne National Laboratory, Argonne, Illinois. Radiological and Environmental Research Division Annual Report, January - December 1976, ANL-76-88, Part IV.

7.1.1.8 WASHINGTON STATE UNIVERSITY HALOCARBON/HYDROCARBON MEASUREMENTS

Principal Investigator	Project Officer
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Funding

EPA Contract No. 68-02-2254
EPA Purchase Order No. DA-6-99-1993J

Period of Performance June 1975 - June 1976

Technical Approach

The purpose of this study was to obtain information on the nature of atmospheric hydrocarbons, to differentiate between natural and anthropogenic origins, and to apply this understanding to the involved chemistry that results in the production of ozone and aerosols.

The experiment was conducted at Glasgow, Illinois about 100 km north of St. Louis, Missouri. Although this area is rural farmland, it is affected by urban pollution under certain meteorological conditions. Fluorocarbon-11 ($CFCL_3$) and acetylene (C_2H_2) were used as indicators of anthropogenic pollutants.

Simultaneous analyses for halocarbons, hydrocarbons and ozone were made. Other measurements included wind speed and direction, solar radiation, temperature and dew point. These analyses and measurements permitted an interpretation of the atmospheric chemistry for four distinct situations:

1) Remote: unambiguously clean and therefore accepted as characteristic of air unaffected by any discernable urban contamination;

2) Near plumes: urban pollutant plumes with easily measurable levels of primary pollutants still reacting in transit over the rural study site;

3) Distant plumes: clearly marked fluorocarbon plumes, with most of the reactive hydrocarbons consumed;

4) Regionally polluted: no plumes noticeable, but clear evidence of photochemical oxidation of hydrocarbons and elevated oxidant.

Period of Data Collection July 16 - August 14, 1975

Parameters Measured	Instrument/Method Used
Non-Methane Hydrocarbons	Hydrocarbon analyses were performed using three Perkin-Elmer flame ionization gas chromatographs. A Perkin-Elmer (PE) Model 990 analyzed hydrocarbons from butane through decane (C_4 to C_{10}). The column used was a 200-ft SCOT OV-101, phase ratio $\alpha = 65$, programmed from 0° to 100°C at 6°C/min. Helium flow rate measured about 7 ml/min. The second instrument, a PE Model 3920, quantified hydrocarbons from ethane through hexane. A 20-ft by 1/16-in. outer diameter (o.d.) stainless steel column packed with Durapak (n-octane/Porasil C) was used. Separation was accomplished when programming from -70° to 65°C at 16°C/min with a flow rate of 7 ml/min of helium. The overlap in carbon number between the two instruments provided a check in determining actual concentrations of individual

Parameters Measured

Instrument/Method Used (continued)

compounds. Total non-methane hydrocarbons then were determined by summing the C_2 through C_4 compounds on instrument two with the C_5 through C_{10} compounds on instrument one. The third instrument, a PE Model 3920, analyzed specifically for ethane, ethylene and acetylene and provided another check on the precision between instruments. The column used was a 5 ft by 1/8 in. o.d., filled with Poropak N, operated isothermally (55°C) with a carrier flow rate of 30 ml/min helium.

Identification of the hydrocarbons was accomplished by periodically injecting a set of standard compounds and then matching their retention times with those from an actual sample. Those peaks with similar retention times were named accordingly. Occasionally an actual sample was "spiked" with a standard to further support identification.

The air samples (500 to 1000 ml) were obtained from the sampling manifold with 100-ml ground-glass syringes. The air was passed through an enrichment trap that was located in front of the chromatographic column. The liquid oxygen Dewar flask used to facilitate the freezeout was replaced with one of hot water (90°C) to assist the transfer of the contents of the traps onto the analytical column.

Parameters Measured	Instrument/Method Used (continued)
Halocarbons (Freon 11, Freon 12, methyl chloroform and carbon tetrachloride)	Halocarbon analyses were performed employing a Perkin-Elmer 3920 electron capture (Ni 63) gas chromatograph. The column was fabricated with a 10-ft by by 1/4-in. o.d. stainless steel tubing packed with 10% SF-96 on Chromosorb W (100-120 mesh). The column oven was operated isothermally at 45°C. Carrier flow (95% Ar-5% CH_4) was 50 ml/min. The ambient air sample was drawn through the sample loop (5-ml volume) with a Metal Bellows pump (MB-41) hooked in line to the sampling manifold. Automatic analyses of Freon-12, Freon-11, methyl chloroform and carbon tetrachloride were conducted every 20 minutes. Halocarbon identification was accomplished by matching retention times with standards. Periodically, samples were obtained outside the field laboratory to check against possible contamination due to leakage in gas sampling system.
Ozone	Meloy Model OA 350-2 ozone analyzer with a built-in calibration system and a minimum detection limit of .0005 ppm.
Wind speed, wind direction, solar radiation, dew point and ambient temperature	

Calibration and Quality Control Procedures

Calibration (hydrocarbon) was accomplished using neohexane as an external standard. Response factors for all hydrocarbons were considered to be one. For example, 32 ng of neohexane has an area response of 1.00 on the PEP-1 computer. This ratio, 32 ng/area of 1.00, is then multiplied by the individual peak areas. The result for each peak is in nanograms per 1000 ml of sampled air, or the equivalent of micrograms per cubic meter of sampled air. Summing the individual hydrocarbons peaks gives a good indication of the total non-methane hydrocarbon burden.

Halocarbon calibration was accomplished by preparing known concentrations in static chambers in the home laboratory. Dilution of the appropriate amount of pure halocarbon species into the chambers gave concentrations simulating ambient air levels to a precision of ± 10%. Reference canisters were then calibrated and shipped to the field site for daily calibration of the instruments.

Zero and calibration checks of the Meloy ozone analyzer were performed daily with a MacMillan Model 1000 ozone generator, which was calibrated in the laboratory by the standard KI method prior to the field sampling period.

Location and Type of Data Available

All data are contained in Appendices A-C of the publication referenced below. Additional information may be obtained from the EPA Project Officer.

Publication

Rasmussen, R. A., R. Chatfield and M. Holden. Hydrocarbon and Oxidant Chemistry observed at a Site Near St. Louis. Washington State University, Pullman, Washington. Final Report, EPA Contract 68-02-2254. June 1977. EPA-600/7-77-056.

7.1.1.9 BATTELLE COLUMBUS HEAVY HYDROCARBON MEASUREMENTS

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-1409, Task Order Nos. 30 and 43

Period of Performance October 1973 - June 1976

Technical Approach

Organic pollutants in urban atmospheres were characterized by analyzing particulate and/or vapor-phase samples collected by the EPA in St. Louis, Missouri; Miami, Florida; Denver, Colorado; Houston, Texas; and at the General Motor Test Track in Milford, Michigan. The samples collected in St. Louis came from Washington University (RAMS Station 112) and RAMS Station 103 with aerial sampling occurring over the Baldwin Power Plant, the Labadie Power Plant, Granite City, and Wood River, Illinois.

The purpose of this experiment was to identify organic species present in both the gaseous and particulate fraction of organic materials collected in an urban area. The particulate and vapor-phase samples were analyzed by solvent extraction followed by elemental combustion analysis and infrared spectroscopic analysis. The vapor-phase samples collected from the atmosphere over St. Louis were analyzed by electron impact and methane chemical ionization gas chromatography-mass spectrometry.

Periods of Data Collection

Samples were collected at various times during the following periods:

October 3-4, 1973
February 26 - March 2, 1974
July 23 - October, 1975

Parameters Measured	Instrument/Method Used
Organic Composition of Aerosols	The samples were collected by the EPA with General Metals hi-vols equipped with an Anderson 2000 High Volume Sampling Heads and treated quartz final filters. The hi-vols were operated from 0000-2400 CST with the flow rate maintained by a Thermal Systems anemometer whose hourly averages were recorded by an on-site data acquisition system. Gaseous samples were collected from an airplane using Chromsorb 102 chromatographic traps without filters. Approximately 300 liters of gas per sample were collected over 20 minute periods. Particulate samples were removed from the filters by extraction with various solvents, including methylene chloride, diethyl ether, benzene and methanol, using Soxhlet extractors and ultrasonic devices. The extracted materials were analyzed for carbon, hydrogen and nitrogen. Infrared spectra of the percarbonyl bond (1770 cm^{-1}), the carbonyl bond (1710 cm^{-1}) and the nitrate bond (1630 cm^{-1}) were obtained. The gaseous samples were recovered by

Parameters Measured

Instrument/Method Used (continued)

thermal desorbtion, followed by freeze-out and then thermal injection onto a gas chromatographic column. Gas chromatographic separation was achieved using a Silar 5CP chromatographic column. Gas chromatographic-mass spectrometry analysis was carried out by methane chemical ionization. About a dozen compounds were tenatively identified as shown in Table 12.

TABLE 12. COMPOUNDS TENTATIVELY IDENTIFIED FROM METHANE IONIZATION GC-MS ANALYSIS OF AMBIENT ST. LOUIS VAPOR SAMPLES

COMPOUND	MW	SAMPLES S7	S5	S6	S1	S3	S4	S8	S9	S10
Styrene	104	X	X	X	X	X	X	X	X	X
Allylbenzaldehyde	132	X	X	X	X	X	X	X	X	X
Benzaldehyde	106	X	X	X	X	X	X	X	X	X
Phenylacetate	136					X	X	X	X	X
Acetophenone	120			X	X	X	X	X	X	X
Naphthalene	128	X	X	X	X	X	X	X	X	X
Terephthaldehyde	134	X	X	X	X	X	X	X	X	X
Phenol	94	X	X	X	X	X	X	X	X	X
Methylnaphthalene	142	X	X	X	X	X	X			
C5-benzene	148	X	X	X	X	X	X	X	X	X
C2-naphthalene	156					X	X	X		
Biphenyl	154			X	X	X	X	X	X	X

Calibration and Quality Control Procedures

Blanks were used to check extraction procedures. Routine calibrations were made for the infrared, gas chromatograph and mass spectroscopy instruments every 24 hours.

Location and Type of Data Available

Available data are contained in the report referenced below. Additional information may be obtained from the EPA Project Officer.

Publication

Mendenhall, G. D., P. W. Jones, P. E. Strup, W. L. Margard. Organic Characterization of Aerosols and Vapor Phase Compounds in Urban Atmospheres. Battelle Columbus Laboratories, Columbus, Ohio. Task Order Nos. 30, 43 Final Report, EPA Contract No. 68-02-1409. March 1978. EPA-600/3-78-031.

7.1.1.10 ARGONNE INFRARED ANALYSIS OF FRACTIONATED AEROSOL SAMPLES

Principal Investigator

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Funding Interagency Agreement IAG-D5-F814

Period of Performance August 1974

Technical Approach

During August of 1974, a 24-day period of continuous sampling was conducted at a site just north of National City, Illinois, at a point about 12 km NE of downtown St. Louis. This site was also occupied by the RAMS Station 103 as a part of the Regional Air Pollution Study (RAPS). It was anticipated that considerable data on meteorology and gaseous pollutant concentration would be available to assist in interpreting the particle chemistry data, but start-up difficulties greatly reduced the amount of supplemental information available. The data collected during this sampling period represent the weight of sample recovered from the Mylar substrate of the stage III and stage IV impactor stages and as such represent a minimum for the weight actually collected.

Period of Data Collection August 5 - 29, 1974

Parameters Measured	Instrument/Method Used
Suspended particulate loading and sulfates	A Lundgren 4-stage Cascade Impactor was used for sample collection. Only

Parameters Measured

Instrument/Method Used (continued)

material collected on stages III and IV was processed. The Mylar substrates used in the impactor were weighed and the sample loading reported both as weight of sample and the equivalent atmospheric loading. Weight of sulfates was determined by infrared absorbance.

Calibration and Quality Control Procedures

The infrared method was calibrated by preparing potassium bromide pellets containing known amounts of ammonium sulfate and determining their absorbance at 620, 1110 and 1400 cm^{-1}. No particular quality control procedures were used.

Location and Type of Data Available

Data summaries were listed in tabular form in the report below and have been placed on magnetic tape. Inquiries may be directed to the Principal Investigator.

Publication

Cunningham, P. T., and S. A. Johnson. Chemistry of Airborne Particulates, Chemical Engineering Division, Argonne National Laboratory, Argonne, Illinois. Environmental Chemistry Annual Report, ANL-15-51.

7.1.1.11 DERIVATIVE SPECTROMETER VAN

Principal Investigator	Project Officer
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Funding EPA Grant

Period of Performance October 1973 - November 1974

Technical Approach

The purpose of this study was to determine the distribution of pollutants in an urban area, using a derivative spectrometer in a mobile application. A total of 350 measurements were made at several locations in the St. Louis area, including the locations of RAMS Stations 106, 107 and 111. Strip chart recorders were used to record the data which were later transferred to computer cards.

Periods of Data Collection

October 23, 1973 - February 1, 1974
August 15 - September 24, 1974
November 8 - November 22, 1974

Parameters Measured	Instrument/Method Used
Ammonia, nitric oxide, carbon monoxide, nitrogen dioxide, sulfur dioxide and ozone	Spectrometrics (Lear Siegler) ultraviolet derivative spectrometer. Concentration measured and reported

Parameters Measured	Instrument/Method Used (continued)
	in ppm.
Carbon monoxide	Ecolyzer CO monitor. Concentration measured and reported in ppm.
Wind speed and direction	R. M. Young wind set (propeller type)

Calibration and Quality Control Procedures

A five point calibration of the spectrometer was performed weekly, using EPA furnished gas standards (NBS traceable) and a bag dilution technique. Internal and wavelength calibrations were performed daily.

The calibration was cross-checked twice using the RAPS helicopter calibration system at Scott Air Force Base (Section 5.0). The standard gases used were NBS traceable.

Location and Type of Data Available

All data were keypunched on computer cards and are available in printout form from the Principal Investigator. They are also contained in the publication referred below.

Publication

Keller, R. Examination of the Concentration Distribution of Six Air Pollutants by Mobile Monitoring. Ph.D. Thesis, University of Missouri, Columbia, Missouri. Available from University Microfilms, Ann Arbor, Michigan. May 1977.

7.1.1.12 MASS SPECTROMETER ANALYSES OF ATMOSPHERIC ORGANIC AEROSOLS

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Funding EPA Grant No. R-801119

Period of Performance June 1972 - October 1975

Technical Approach

The prime objectives in the work were (1) to examine the usefulness of high-resolution mass spectroscopy without prior chemical separations in determining the composition of the organic portion of atmospheric aerosols and (2) to investigate the composition of real aerosol samples at various urban sites. Six sets of samples were obtained in the St. Louis area, in collaboration with the Regional Air Pollution Study. Samples were taken on the "intensive study" days to permit future comparison with other work. The Tyson Valley site was used to provide a rural site near St. Louis. Sampling site locations were:

Washington University, 1973 - height, 4 meters at the top of the EPA trailer on the campus of Washington University on the soccer field near the intersection of Forsythe and Big Bend.

Washington University, 1974 - height, 10 meters on tower at east end of Francis field on the campus of Washington University north of Forsythe.

Holiday Inn, 1973 - height, 50 meters on top of Holiday Inn hotel in downtown St. Louis.

National City, 1974 - height, 4 meters on top of EPA trailer in the industrial area in National City, Illinois.

Tyson Valley, 1973 - height, 6 meters on tower mounted on truck at Tyson Valley reservation, a wooded area about 35 km southwest of St. Louis.

Tyson Valley, 1974 - height, 2 meters on roof of old radio shack at Tyson Valley.

Samples studied in this work were collected using an apparatus which consisted of an impactor designed to collect particles of larger diameter than 1 or 2 micrometers on small gold plates. Following the impactor, Gelman Type A glass fiber filters were used to collect fine particles. The impactor back-up was always used, whether or not the large particles were later examined. The glass filters and impactor plates were cleaned by heating to 550°C. for 24 hours. They were then stored in glass vials with Teflon lined caps. After sampling, the filters and impactor plates were returned to glass vials and cooled to dry-ice temperature. Samples were maintained at dry-ice temperature during shipment and storage until just before introduction into the mass spectrometer. Filters and impactor plates were handled with tools which had been flamed to remove organic materials, and handling was carried out in a clean zone of aluminum foil. In the examination of a sample, material was evaporated from the spectometer probe into the ion source over a period of time as the temperature of the probe was raised in a programmed manner. During this time, a series of mass spectra of the effluent gases was recorded. From these, plots of ion abundance against temperature-time were made for specific ions. These plots were called "mass thermograms". Similar profiles from different thermograms implied that the ions originated from compounds evaporated at the same temperature. If the spectum of a suspect compound was known from the literature or could be reasonably deduced from the spectra of related compounds, the ions expected to be produced in large amounts could be determined. The compound could be identified by the appearance of similar mass thermograms for the ions expected. Care was taken in anticipating alternate compounds of similar spectra. Many compounds were originally identified in this way from studies of samples containing relatively large amounts. Other samples may be of such low concentration that only the major ion was seen. It was assumed that the origin of the major ion remains the same. This was a risky procedure, but appeared to be the best that could be followed.

Periods of Data Collection

Samples were collected at Washington University on September 5 to September 7, 1973, and August 19 - 21, 1974. At the Holiday Inn, samples were collected September 5 - 11, 1973. In National City, sample collection occurred on August 19 - 21, 1974. Tyson Valley samples were gathered September 4 - 11, 1973.

Parameters Measured	Instrument/Method Used
Organic aerosol species	An Associated Electronics Industries Type MS 9 mass spectrometer, having Nier-Johnson geometry, was used in this work. The resolving power was set to 7000 to 10,000. The spectrometer was interfaced to a Digital Equipment Corporation PDP-12 computer. During operation, the computer provided the timing for initiation of spectral scans and recorded the spectral data on magnetic tape. The same computer was used off-line for subsequent data processing. As is common in high-resolution mass spectrometry, perfluorokerosene was admitted to the ion source during scans to provide ions of known mass to serve as mass markers. Because of the large number of fluorine atoms in these ions, they are mass deficient and are seldom confused with ions from other compounds.

Parameters Measured

Instrument/Method Used (continued)

From these studies, chemical species found in aerosols were classified into several groups, such as alkones and alkenes, pinene and terpenes, aromatic hydrocarbons, polynuclear aromatic hydrocarbons, aromatic oxygenated compounds, and others. Diurnal variations in the abundance of compounds were examined in an effort to deduce the source of emissions.

Calibration and Quality Control Procedures

The computer was provided with a spectrum of the perfluorokerosene used as a marker. The computer required operator interaction to identify a few of the perfluorokerosene peaks in the aerosol spectrum with perfluorokerosene peaks in the known spectrum. The computer programs then attempted to identify a series of selected perfluorokerosene peaks in the aerosol spectrum by comparing the two spectra. Usually 45 to 48 peaks were identified. If identifications were not satisfactory, operator interaction was used. Once the perfluorokerosene was identified, these known masses were used as mass standards. The masses of other peaks in the aerosol spectrum were then calculated by interpolation between known peaks on a time basis. Masses were calculated to 0.0002 atomic-mass units, with errors seldom exceeding 0.0003 atomic-mass units. The calculated masses and peak intensities were logged on magnetic tape and were displayed or printed out. The set of observed mass thermograms was printed out and examined for erroneous mass identifications and, if needed, corrections were made by the operator. Similar mass thermograms and printouts were used for sensitivity calibration runs on o-bromobenzoic acid. The thermograms were ion intensities as functions of time. The average area under the thermograms for the four intense peaks for o-bromobenzoic acid were divided by the weight of o-bromobenzoic acid and used to obtain instrument sensitivity factors.

Location and Type of Data Available

A computer list of the results of all analyses is contained in an Appendix to the report referenced below. Further information may be obtained from the Principal Investigator.

Publication

Crittenden, A. L. Analysis of Air Pollutants by Mass Spectroscopy. University of Washington, Seattle, Washington. Final Report, EPA Grant R-801119. August 1976. EPA-600/3-76-093.

7.1.2 POWER PLANT PLUME MAPPING

7.1.2.1 BROOKHAVEN INSTRUMENTED CESSNAS

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Funding

EPA Interagency Agreement No. IAG-D4-0391
ERDA Contract No. E(30-1)-16

Periods of Performance

June - August 1974
July - October 1975

Technical Approach

Measurements of particulate sulfur to total sulfur concentration ratios and ^{34}S:^{32}S isotope ratios were employed to determine the percent of sulfur dioxide converted to sulfate in the plumes of the Labadie and Portage des Sioux power plants. A Cessna 182 and/or 206 was outfitted with a high-volume impregnated filter assembly to collect samples. A variety of parameters were investigated including relative humidity ranging from 32 to 85%, temperatures from 10° to 25°C, distances as far as 70 km and times as long as 200 min. Generally, the extent of SO_2 oxidation seldom exceeded 5% with essentially all of the observed oxidation occurring within the first few kilometers after emission. The observations are interpreted as indicative of a heterogeneous mechanism with the consumption or poisoning of available catalyst. No distinct correlation was found between the extent of sulfur dioxide conversion with distance, travel time, temperature, relative humidity, time of day or atmospheric stability. Plume reproducibility measurements were made, aircraft flight patterns compared and fringe effects investigated. An extensive body of information has been obtained and should serve as a reference for future investigations.

Periods of Data Collection

June 12-18, 1974
July 30 - August 5, 1974
July 22-30, 1975
September 30 - October 8, 1975

Parameters Measured	Instrument/Method Used
Sulfur Dioxide and Sulfate	Samples of the power plant plumes were obtained with a single-engine Cessna by means of a 8 x 10 in. high-volume filter assembly containing a glass-fiber particulate filter (Whatman 81) for sulfate collection followed by two KOH-triethanolamine impregnated cellulose papers (Schleicher and Schuell Fast Flow No. 2W) to absorb SO_2. During the 1975 experiments at Labadie, the glass-fiber prefilter was replaced by Pallflex Tissuquartz filters, pretreated to neutralize alkaline sites. This modification made possible chemical speciation of plume sulfate particulates with emphasis upon measurement of sulfuric acid. Pretreatment of the quartz filters consisted of first heating overnight at 700-750°C, subsequently rinsing with 2-3 l. of distilled water using suction, drying at 110°C, soaking in hot 85% H_3PO_4 at steam bath temper-

Parameters Measured	Instrument/Method Used (continued)
	atures for 30 min., rinsing thoroughly with 10-15 l. distilled water using suction, and finally drying. During the October 1975 series at Labadie, 4 in. dia. filter packs replaced the 8 x 10 in. package. Analyses for the amount of SO_2 and SO_4^{2-} collected on the filter pack were performed by a procedure which utilizes ^{110}Ag. Briefly, the collected sulfur compounds were reduced to H_2S, distilled over into cadmium acetate to precipitate the sulfide, and metathesized with $AgNO_3$ containing tracer ^{110}Ag to form Ag_2S which was separated and counted. When isotope ratios ($^{34}S:^{32}S$) were desired, the Ag_2S was converted to SO_2 by combustion with oxygen and the isotope ratios measured with a mass spectrometer. Background (i.e. upwind of the plume) concentrations were measured in each instance and this value was subtracted from the plume sample concentrations to obtain solely the power plant plume contribution to the sample.
Wind direction and wind speed	10 gram (day) or 30 gram (night) pilot balloon observations using the single theodolite method. See Section 7.1.2.2 for more detailed information.

The temperature and humidity measurements were made with equipment in the aircraft, with vertical spirals flown to determine atmospheric stability.

Calibration and Quality Control Procedures

There were no calibration and quality control procedures for sample collection. However the analytical procedures were checked with spiked samples.

Location and Type of Data Available

Data are presented in the publication referenced below. Additional information may be obtained from the EPA Project Officer.

Publication

Forrest, J., and L. Newman. Further Studies on the Oxidation of Sulfur Dioxide in Coal-Fired Power Plant Plumes. Atmospheric Environment, 11:465-474, 1977.

7.1.2.2 MOBILE PIBAL SUPPORT

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Funding

EPA Contract No. 68-02-1081, Task Order Nos. 33 and 59
EPA Contract No. 68-02-2093, Task Order No. 105

Periods of Performance

Task Order No. 33 - June 1974
Task Order No. 59 - July 1975
Task Order No. 105 - September - October 1975

Technical Approach

The objective of the Brookhaven plume studies (Section 7.1.2.1) was to determine the conversion rates of sulfur dioxide (SO_2) to particulate sulfate and nitric oxide (NO) to nitrogen dioxide (NO_2) within tall stack plumes from power generating plants. To correlate the results obtained by stack sampling and airborne measurements of the plume with the existing meteorological conditions, it was necessary to characterize the low-level wind field to determine the existing transport mechanism. In order to define the existing transport wind, mobile pilot balloon (pibal) observations were obtained at 20 minute intervals near the Labadie and Portage des Sioux power plants.

Periods of Data Collection

June 12-18, 1974
July 22-30, 1975
September 30 - October 8, 1975

Parameters Measured	Instrument/Method Used
Wind speed and wind direction	10 or 30 gram pilot balloon (pibal) observations using the single theodolite method. Calculated wind speed and wind direction from angular values observed at a constant time interval of 30 seconds.

Calibration and Quality Control Procedures

Except for the minimum observation being five minutes (weather permitting), all pibals were released in accordance with Upper Air Sounding Network procedures (Section 4.0). Because mobile pibal site orientation points have to be determined, a compass with sighting apparatus was used at each site to locate a reference point for Magnetic North. A reference point for True North was then established from U.S. Geological Survey maps.

Quality Control procedures included reviewing elevation and azimuth angles for angular continuity and checking for correct magnetic declination. Theodolites were checked and collimated prior to each study period. Theodolite orientation was checked before and after each pibal release.

Information Concerning Data Collection

Information concerning data collection or any additional information may be obtained by contacting the EPA Task Coordinator, Francis A. Schiermeier.

Location and Type of Data Available

Data are available as part of the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Jones, A. C. Labadie Plume Study - Meteorological Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 33 Final Report, EPA Contract 68-02-1081. July 1974.

Waldron, T. L. Brookhaven Plume Study Pibal Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 59 Final Report, EPA Contract 68-02-1081. October 1975.

Waldron, T. L. Brookhaven Plume Study Pibal Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 105 Final Report, EPA Contract 68-02-2093. December 1975.

7.1.3 PLUME TRACER STUDY (MISTT)

7.1.3.1 CALIFORNIA INSTITUTE OF TECHNOLOGY SF_6 TRACER RELEASE

Principal Investigator	Project Officer
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Funding EPA Grant No. R802160-03-2

Period of Performance February 1975 - March 1976

Technical Approach

Five full-scale tracer releases were conducted in St. Louis between August 8 and 15, 1975. The purpose of these studies was to characterize the transport and dispersion of plumes emitted at ground and elevated levels.

During the studies, 63 grab samples were analyzed from four airborne traverses, 2162 grab samples from 50 automobile traverses, and 929 hourly averaged air samples from 20 fixed locations. A total of 3154 air samples were analyzed during the five field tests.

Data from 37 of the automobile traverses were used to calculate cross-wind standard deviations associated with the Gaussian plume model. In 25 automobile traverses, the average wind direction determined from the tracer data was ± 10° of that obtained by averaging the RAMS hourly averaged data.

Period of Data Collection August 8 - 15, 1975

Parameters Measured	Instrument/Method Used
Sulfur Hexafluoride (SF_6)	To obtain continuous air sampling at stationary ground locations, nine hourly-sampling syringe units were installed on the roofs of RAMS Sites 102, 110, 112, 114, 115, 117, 119, 120, and 121. Each sequential air sampling unit consisted of a timing mechanism (electrically driven) and twelve syringes mounted on a board. The calibrated timing mechanism allowed the plunger of each syringe to be sequentially retracted, drawing air into the syringe reservoir over a period of one hour. These sampling units provided hourly averaged air samples for SF_6 analysis for twelve consecutive hours (from 2-3 hours before tracer release to 4-5 hours after release termination) at each of the selected RAMS stations. For automobile traverses, grab samples were collected in 30 cm^3 plastic syringes. A similar system was used for airborne sampling.

Samples were analyzed by electron capture chromatography, using a Loenco Model 70 portable gas chromatograph, equipped with a Spectra Physics Autocab System I Integrator.

Calibration and Quality Control Procedures

The instruments were calibrated using an exponential dilution system. The detection limit was approximately 10^{-12} parts SF_6 per part of air.

During the sampling period, the SF_6 chromatographs were cross-checked against each other with a constant concentration sample. The cross-check results indicated that the response characteristics of the chromatographs had a probable uncertainty of ± 15% with ± 24% in the worst case.

Location and Type of Data Available

All raw data are contained in the preliminary report. Additional information may be obtained by contacting the principal investigator.

Publication

Lamb, B. K., J. D. Bruchie, and F. H. Shair. Tracer Studies for Characterizing the Transport and Dispersion of Plumes Emitted at Ground and at Elevated Levels. California Institute of Technology, Pasadena, California. Preliminary Report, EPA Grant No. R802160-03-2. October 1975.

7.1.3.2 SF_6 TRACER RELEASE SUPPORT

Principal Investigator	Task Coordinator
Albert C. Jones	William E. Wilson (MD-84)
Rockwell International	Environmental Protection Agency
Hanford Operations	Environmental Sciences Research Laboratory
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Funding EPA Contract No. 68-02-1081, Task Order No. 63

Period of Performance June - December 1975

Technical Approach

The purpose of this task order was to provide technical support for the Plume Tracer Study (Section 7.1.3.1) conducted in St. Louis between August 8 and 15, 1975.

Tracer release site surveys and selection discussions were held at a meeting between the EPA Task Coordinator and members of the Rockwell International Air Monitoring Center. Two high plumes, similar to the Labadie power plant, and a low plume such as that from an industrial boiler with a relatively short stack were recommended. Stacks at the Union Electric power plants and Washington University were to be used for tracer releases. However, a strike at Union Electric forced the investigation of alternate power plants or other test methods. It was then decided to perform tracer releases from the towers at RAMS Sites 111, 113, 119, 120 and from the KETC television station tower located in south St. Louis county.

At the four RAMS towers, copper tubing was installed from the base to the top (30 meters) of each tower. At RAMS Sites 111 and 113, additional copper tubing was installed at the ten meter level. At the television tower, copper tubing was installed from the base to 61 meters and connected to garden hose installed to the tower top (328 meters). The installation of these tracer release lines permitted the SF_6 gas cylinders to be conveniently located at the base of the towers.

Sequential air sampling units were received from the California Institute of Technology. The units were inspected and repaired prior to installation at selected RAMS sites.

Manpower was provided to assist in the operation of the sequential air sampling units and the release of the SF_6 tracer gas. Two leased vans were utilized to house the SF_6 gas cylinders and flow controllers during their installation and operational periods. Pilot balloons (pibals) were occasionally used to visually estimate wind directions up to approximately 610 meters.

At the termination of the tracer study, all sequential air sampling units, gas cylinders and flow controllers were removed from the RAMS sites and television tower and returned to the Principal Investigator.

Publication

Jones. A. C. Summer 1975 SF_6 Tracer Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 63 Final Report, EPA Contract 68-02-1081. December 1975.

7.2 PHOTOCHEMICAL REACTION STUDIES

7.2.1 HYDROCARBON CHARACTERIZATION BY GAS CHROMATOGRAPHY

Introduction

In late 1973 and early 1974, a gas chromatograph laboratory was set up at the RAPS Central Facility in St. Louis in support of the Regional Air Pollution Study. The laboratory was equipped to chemically analyze bag samples originating from several different RAPS activities. Among the sources of bag samples were: The Regional Air Monitoring System (RAMS) stations, airborne sampling, highway sampling, plume tracking, and photochemical model verification studies.

Over its three years of operation, the gas chromatography laboratory made changes in instrumentation and analytical procedures. What follows is a survey of the data collection activities of the gas chromatography laboratory, done on a task order by task order basis to reflect these changes and to chronologically organize the laboratory operations.

Task Order No. 3

Principal Investigator

John Q. Walker
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Under Contract To:
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11640 Administration Drive
Creve Coeur, MO 63141

(314) 567-6722

Task Coordinator

Stanley L. Kopczynski (MD-47)
Environmental Protection Agency
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Research Triangle Park, NC 27711

(919) 541-3064

Funding EPA Contract No. 68-02-1081, Task Order No. 3

Period of Performance August 1973 - February 1974

Periods of Data Collection

Analyses performed under Task Order No. 3 were not routine, but were part of the initial laboratory set-up and development of standard analytical procedures. Therefore, sampling periods cannot be delineated.

Almost all samples were taken at the RAPS Central Facility, 11640 Administration Drive, Creve Coeur, Missouri, 63141.

Parameters Measured	Instrument/Method Used
C_1 - C_{10} hydrocarbon concentrations, sensitivity 0.1 ppb	Perkin Elmer Model 900B Gas Chromatograph and Model PEP-1 Laboratory Computer System.
Methane, Carbon Monoxide concentrations, sensitivity 10 ppb for CO, 0.1 ppb for CH_4	Beckman Model 6800 Gas Chromatograph
Used for data recording	Houston Omni Scribe Model 5213-4 Dual Pen Recorder

Calibration and Quality Control Procedures

Perkin Elmer 900B	Routine calibration was not performed since only a few special tests were run. However, problems were encountered with the squalane column.
Beckman 6800	A mixture of 45 ppm CO, 5 ppm CH_4, 5 ppm C_2H_4 and 5 ppm C_2H_2 in nitrogen mixture was also used. Problems were encountered with the circuit boards and molecular sieve column. One problem of particular concern was the poor repeatability of results.

Location and Type of Data Available

Data, in the form of notebooks and chromatograms, have been submitted to EPA and may be obtained from the Task Coordinator.

Publication

Jones, A. C. Gas Chromatographic Analyses of Atmospheric and Source Samples. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 3 Final Report, EPA Contract 68-02-1081. October 1975.

Task Order No. 21

Principal Investigator

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Task Coordinator

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Funding EPA Contract No. 68-02-1081, Task Order No. 21

Period of Performance March - November 1974

Periods of Data Collection

Data collection occurred from March 1974 to November 1974. Bag samples were nominally collected from selected RAMS sites at variable intervals. Additional sources of samples during the Summer 1974 Field Expedition were the Long Path Monitoring (Section 8.2.1) and Pollutant Variability Studies (Section 8.1) and the EPA/RAPS helicopters (Section 5.0). Some of the samples for the Long Path Monitoring and Pollutant Variability Studies were collected in aluminum cylinders.

Parameters Measured	Instrument/Method Used
C_2 - C_{10} hydrocarbon concentrations, sensitivity 0.1 ppb	Perkin Elmer Model 900B Gas Chromatograph and Model PEP-1 Laboratory Computer System
Methane (CH_4), Carbon Monoxide (CO), Total Hydrocarbons (THC) and C_2	Beckman Model 6800 Gas Chromatograph

Parameters Measured	Instrument/Method Used (continued)
hydrocarbon concentrations, sensitivity 10 ppb for CO, 0.1 for CH_4, THC and C_2	
Sulfur Dioxide (SO_2), Hydrogen Sulfide (H_2S), Total Sulfur, and Methyl Mercaptan concentrations, sensitivity 0.1 ppb.	Tracor Model 270 Sulfur Chromatograph

Calibration and Quality Control Procedures

Perkin Elmer 900B	Standards, prepared weekly, consisted of a mixture of eight different hydrocarbons in the C_2 to C_8 range, combined in a Teflon or Tedlar bag containing a known amount of Linde zero air. Precision syringes were used to inject known amounts of gases in making up the standards.
Beckman 6800	Synthetic standards were prepared daily consisting of CO and CH_4, at approximate ambient concentrations, combined in a Teflon bag containing a known amount of Linde zero air. Precision syringes were used to inject known amounts of gases in making up the standards. Reproducibility was checked periodically.
Tracor 270	Calibration was not performed on a routine basis, since the instrument was not used routinely. In an effort to improve repeatability, Teflon bags were preconditioned before use. Immediate analysis after sample collection was found to be essential due to the instability of SO_2 in the Teflon bags.

Calibration and Quality Control Procedures (continued)

Sample bags were cleaned prior to use. Impurity hydrocarbons were removed by evacuating the bags. A study of diffusion losses through Teflon and Tedlar bags was made, however, no conclusive results were obtained.

A great deal of effort was expended in column development for the Perkin Elmer 900B for better resolution of C_2 - C_4 hydrocarbons. Also, the Beckman 6800 was modified for greater sensitivity to C_2 hydrocarbons, since it was not meeting RAPS requirements.

The validity of the C_2 - C_{10} hydrocarbon data from the Perkin Elmer 900B chromatograph is questionable due to sample contamination from the chromatograph carrier gas.

Location and Type of Data Available

All chromatograms and PEP-1 computer outputs were transferred to coding forms and stored on magnetic tape (9 track odd parity). Data tapes were submitted to the RAPS Data Bank and may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

A computer printout of sampling data and sources of samples is available upon request from the RAPS Data Bank.

Publication

Jones, A. C. Gas Chromatography Laboratory Operation. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 21 Final Report, EPA Contract No. 68-02-1081. March 1976.

Task Order No. 53

Principal Investigator	Task Coordinator
Raymond F. Mindrup, Jr. Rockwell International	Stanley L. Kopczynski (MD-47) Environmental Protection Agency

Principal Investigator

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Task Coordinator (continued)

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Research Triangle Park, NC 27711

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Funding EPA Contract No. 68-02-1081, Task Order No. 53

Period of Performance December 1974 - August 1975

Periods of Data Collection

Bag samples were nominally collected every 3 days from December 1974 to August 1975 at RAMS Sites 101 - 109, 111 - 116, 118 - 125 and from the EPA/RAPS helicopters during the Summer 1975 Field Expedition.

Parameters Measured	Instrument/Method Used
C_2 - C_{10} hydrocarbon concentrations, sensitivity 0.1 ppb; C_2 - C_5 analysis with silica gel column; C_4 - C_{10} analysis with Support-Coated-Open-Tubular (SCOT) squalane column	Perkin Elmer Model 900B Gas Chromatograph and Model PEP-1 Laboratory Computer System
Carbon Monoxide (CO), Methane (CH_4) and Total Hydrocarbon Concentration (THC), sensitivity 10 ppb for CO, 0.1 ppb for CH_4 and THC	Beckman Model 6800 Gas Chromatograph
Total oxides of nitrogen (NO_x) concentrations, sensitivity 5 ppb	Bendix Model 8101-B NO_x Analyzer
Sulfur Hexafluoride (SF_6) and fluorocarbon concentrations, sensitivity 20 ppt, and 500 ppt, respectively	Varian Model 940 Chromatograph with an electron capture detector
Used for calibrations	Bendix Dynamic Calibration System and Pure Air System

Parameters Measured	Instrument/Method Used (continued)
Used for data recording	Houston Omni Scribe Model 5213-4 Dual Pen Recorder.

Calibration and Quality Control Procedures

Perkin Elmer 900B	Under Task Order No. 53, a new column system was installed for better separation of C_2 - C_{10} hydrocarbons. A reproducibility study with the PE 900B was undertaken to determine its reliability and proved satisfactory. Calibrations were carried out daily using standard mixtures of hydrocarbons in hydrocarbon-free air. Concentrations were verified by NBS standards.
Beckman 6800	A reproducibility study was carried out to determine the precision of the Beckman 6800. The results proved to be satisfactory. Daily three-point calibrations were run with standard mixtures of CH_4 and CO in hydrocarbon-free air. Five-point calibrations of THC, CH_4 and CO analyses were performed periodically with the same standard.
Bendix NO_x Analyzer	Daily calibrations were performed by diluting an NBS traceable quality control standard of 100 ppm NO in nitrogen gas to 400 ppb NO with the Bendix Dynamic Calibration System and using this as a calibration standard. Periodic five-point calibrations were conducted monthly using the Bendix Dynamic Calibration System and the above mentioned standard.

Calibration and Quality Control Procedures (continued)

Varian 940 Chromatograph	Daily calibration was performed using the standards prepared from 99% purity fluorocarbon 11 and 12, and SF_6 in hydrocarbon-free air.
Bendix Dynamic Calibration System	This system was itself calibrated every three months by plotting flow rate versus pressure applied for each of the seven capillaries. The constant temperature bath was checked at the same time. At six month intervals, the pressure gauges were checked.

All laboratory standards were NBS traceable. Tedlar sample bags were found to have a high THC build-up and consequently their use was limited to CO and CH_4 analysis. However, the CH_4 - CO analysis was affected by problems of methane contamination in the hydrogen carrier gas of the Beckman 6800. This fact casts serious doubt on the validity of some of the Beckman 6800 data for the period of Task Order No. 53. The validity of analyses conducted on the Perkin Elmer 900B is also questionable due to suspected contamination of samples from the chromatograph carrier gas.

Location and Type of Data Available

All chromatograms and PEP-1 computer outputs were transferred to coding forms and stored on magnetic tape (9 track, odd parity). Data tapes were submitted to the RAPS Data Bank and may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

A computer printout of sampling dates and sources of samples is available upon request from the RAPS Data Bank.

Publication

Mindrup, R. F. Gas Chromatography Laboratory Operation. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 53 Final Report, EPA Contract 68-02-1081. May 1976.

Task Order No. 103

Principal Investigator	Task Coordinator
Gary W. Seeger Rockwell International Air Monitoring Center 11640 Administration Drive Creve Coeur, MO 63141 (314) 567-6722	Stanley L. Kopczynski (MD-47) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-3064

Funding EPA Contract No. 68-02-2093, Task Order No. 103

Period of Performance August 1975 - April 1976

Summary

In addition to bag sampling, this task order included two related investigations: an evaluation of 2 mil versus 5 mil Teflon bags, and a test of a modified bag sampling system.

In evaluating 2 mil and 5 mil bags, the 2 mil bags were used exclusively from the beginning of the task order until the end of 1975. However, the bags proved very troublesome during this period, susceptible to leakage and generally too fragile to withstand normal handling. Evaluation of the 5 mil Teflon bags showed them to be leak-free, however, further experimentation proved the permeability of both Teflon bags to hydrocarbons. Hence, to minimize this problem, laboratory analyses of sample bags took place within 12 hours of sampling.

In an attempt to improve the performance of the bag sampling system in the RAMS stations, a prototype installation of a proposed improved sampling system was made at Station 120 on October 13, 1975. Concurrent with the installation and evaluation of the modified system in Station 120, the flow rates at the other RAMS stations were adjusted to reduce the nominal collected volume from 80 liters to 50 liters. This reduction in volume caused an immediate increase in the percentage of acceptable samples collected, thus identifying over-filling of the Teflon bags as one of the major problems in the sampling program. Because of this revelation, plans to modify more bag sampling systems were dropped and the prototype installation was removed January 14, 1976.

The EPA Task Coordinator stopped analyses for NO_x in February 1976 due to a laboratory experiment indicating that NO_2 significantly decreased upon storage in 5 mil Teflon. NO was found not to adhere on the walls of the bags. It was recommended that all NO_x bag analyses be discontinued and past results be invalidated. Since NO_x data were readily available from RAMS stations, there was no real need for bag analyses.

Two additional problems occurred during Task Order No. 103. One problem involved the diffusion of hydrocarbons through the Teflon sample bags. The other problem was the contamination of samples by impurities in the helium carrier gas used in the gas chromatographs. These two problems make some of the results questionable for analyses performed using the helium carrier gas. Subsequent to this date, special cryogenic traps were installed to remove contaminants from the helium carrier and backflush gas. The validity of the C_2 - C_{10} hydrocarbon analyses from the Perkin Elmer 900B chromatograph prior to January 1976 is therefore questionable because of this possible sample contamination from the carrier and backflush gas.

Periods of Data Collection

Data collection took place from August 1975 to April 1976 with the Winter 1976 Field Expedition conducted during this period. Bag samples were nominally collected at selected RAMS sites every 3 days. Additional sources of samples were roadside locations and the Continuous Air Monitoring Program (CAMP) station daily from January 7 to February 6, 1976.

Parameters Measured	Instrument/Method Used
C_2 - C_{10} hydrocarbon concentrations, sensitivity 0.1 ppb; C_2 - C_5 analysis with silica gel column; C_4 - C_{10} analysis with SCOT squalane column	Perkin Elmer Model 900B Gas Chromatograph and Model PEP-1 Laboratory Computer System

Parameters Measured	Instrument/Method Used (continued)
Carbon Monoxide (CO), Methane (CH_4) and Total Hydrocarbon Concentrations (THC), sensitivity 10 ppb for CO, 0.1 ppb for CH_4 and THC	Beckman Model 6800 Gas Chromatograph
Total oxides of nitrogen (NO_x) concentrations, sensitivity 5 ppb	Bendix Model 8101-B NO_x Analyzer
Total oxides of nitrogen (NO_x) concentrations, sensitivity 5 ppb	Thermo-Electron NO_x Analyzer
Sulfur Hexafluoride (SF_6) and fluorocarbon concentrations, sensitivity 0.1 ppb and 500 ppb, respectively	Varian Model 940 Chromatograph with an electron capture detector and a Texas Instrument 1 MV Chart Recorder
Used for calibrations	Bendix Dynamic Calibration System and Pure Air System
Used for data recording	Houston Omni Scribe Model 5213-4 Dual Pen Recorder

Calibration and Quality Control Procedures

Perkin Elmer 900B

C_2 - C_5 Analysis - Initial calibrations were performed using standards prepared in Teflon bags with known amounts of ultrapure air and hydrocarbons. Each of the C_2 - C_5 hydrocarbons was prepared in this manner at a known concentration so that its "response factor" could be determined on the PE 900B. Daily calibrations were performed using a stainless steel cylinder pressurized with ambient air. The concentration of propane in the air drawn from the cylinder was used for standardization. This concentration was determined prior to the start of regular analyses each day.

C_4 - C_{10} Analysis - This was the same as the C_2 - C_5 analysis calibration except that for daily calibration toluene was used instead of propane.

Calibration and Quality Control Procedures (continued)

Beckman 6800

On a monthly basis, five-point calibrations were performed using a Scott cylinder of CH_4 and CO. This cylinder was then diluted for the multi-point calibrations. Response was tested for THC, CH_4, and CO. Daily calibrations were also performed using Scott standard gases. The Scott cylinders were analyzed at the beginning of Task Order No. 103 and checked against an NBS standard.

Bendix NO_x Analyzer

Five-point calibrations were performed monthly using an NBS standard. Daily calibrations were performed by diluting a quality control standard of 100 ppm NO in nitrogen gas to 400 ppb with the Bendix Calibration System. The quality control standards themselves were calibrated monthly against an NBS standard.

Thermo-Electron NO_x Analyzer

Same calibration procedures as the Bendix NO_x analyzer.

Varian 940 Chromatograph

Daily calibration for SF_6 analyses was performed using a standard prepared by injecting a known amount of SF_6 into a 150 liter Tedlar bag filled with Linde zero air. Fluorocarbon analysis calibration was performed using standards prepared by injecting known amounts of fluorocarbons 11 and 12 into 150 liter Tedlar bags filled with Linde zero air.

Bendix Dynamic Calibration System and Pure Air System

The instrument was calibrated in August 1975 and January 1976. Flow rate versus pressure applied was plotted for each of the seven capillaries. The constant temperature bath and the pressure gauges were checked for proper operation.

Location and Type of Data Available

All chromatograms and PEP-1 computer outputs were transferred to coding forms and stored on magnetic tape (9 track, odd parity). Data tapes were submitted to the RAPS Data Bank and may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

A computer printout of all sampling dates and sources of samples is available upon request.

Publication

Seeger, G. W. and D. H. Hern. Gas Chromatography Laboratory Operation. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 103 Final Report, EPA Contract 68-02-2093. December 1976.

Task Order No. 113

Principal Investigator

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Task Coordinator

Stanley L. Kopczynski (MD-47)
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Funding EPA Contract No. 68-02-2093, Task Order No. 113

Period of Performance April 1976 - February 1977

Periods of Data Collection

Data were collected in the period from June to November 1976 which included the Summer 1976 and Fall 1976 Field Expeditions. Bag samples were nominally collected at selected RAMS sites 2 days per week and at roadside locations during September and October.

Parameters Measured	Instrument/Method Used
C_2 - C_{10} hydrocarbon concentrations, sensitivity 0.1 ppb; C_2 - C_5 analysis with Dura Pak phenyl isocyanate column; C_6 - C_{10} analysis with SCOT squalane column	Perkin Elmer Model 900B Gas Chromatograph and Model PEP-1 Laboratory Computer System
Carbon Monoxide (CO), Methane (CH_4) and Total Hydrocarbon Concentrations (THC), sensitivity 10 ppb for CO, 0.1 ppb for CH_4 and THC	Beckman Model 6800 Gas Chromatograph
Used for data recording	Houston Omni Scribe Model 5213-4 Dual Pen Recorder

Calibration and Quality Control Procedures

Perkin Elmer 900B

C_2 - C_5 Analysis - Daily calibration was carried out with a cylinder pressurized with ambient air (secondary standard). One five-point calibration was performed using the primary standard, 5 ml of propane gas in 50 liters of ultrapure air. In addition to calibrations, duplicate analyses were run for quality control.

C_5 - C_{10} Analysis - Daily calibration was performed using a cylinder pressurized with ambient air (secondary standard, .0500 ml liquid toluene in 50 liters ultrapure air. Duplicate analyses were run for quality control.

Beckman 6800

Scott-Marrin gases were used as calibration standards. The primary standard, Scott-Marrin L1749, was used to check the secondary standard cylinders, Scott-Marrin L2327 and L2359, which were used for daily calibrations. Before being used in the gas chromatography laboratory, the primary standard was analyzed by EPA personnel at Research Triangle Park, North Carolina. Small amounts of methane and carbon monoxide in air made up the primary standard.

The first daily sample on the PE 900B was analyzed three times to check the instrument's performance. For both the PE 900B and the Beckman 6800, duplicate analyses were run at the beginning and end of the sample day to insure stability of the instruments.

Location and Type of Data Available

All chromatograms and PEP-1 computer outputs were transferred to coding forms and stored on magnetic tape (9 track, odd parity). Data tapes were submitted to the RAPS Data Bank and may be obtained from:

RAPS Data Manager (MD-80)
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A computer printout of all sampling dates and sources of samples is available on request.

Publication

Cardwell, G. Gas Chromatography Laboratory Operation. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 113 Final Report, EPA Contract 68-02-2093. June 1979.

7.2.2 BAG IRRADIATION STUDIES

Principal Investigators

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Funding

Program Element 1AA008, Research Objective Achievement Plan 21AKC, Task 16

Period of Performance October 1974 - March 1975

Technical Approach

A bag irradiation study was undertaken in November 1974 to obtain chemical reaction rate data for atmospheric photochemical modeling. Polyvinyl fluoride (Tedlar) bags were used as the reaction containers. The Tedlar bags were irradiated artificially with a bank of sunlamps and afterwards were chemically analyzed.

Periods of Data Collection

The bag irradiation experiments took place in 1974 from October 21 to November 22 and from November 30 to December 18. All experiments were performed at the RAPS Central Facility.

Parameters Measured	Instrument/Method Used
Oxides of Nitrogen, Nitrous Oxide	Bendix Model 8101-B NO_x Analyzer
Ozone	Bendix Model 8002 Ozone Analyzer

Parameters Measured	Instrument/Method Used (continued)
Sulfur Dioxide	Tracor Sulfur Analyzer
C_1 - C_{10} Hydrocarbon Concentration	Perkin Elmer Model 900 Gas Chromatograph
Carbon Monoxide, Methane, Total Hydrocarbons	Beckman Model 6800 Gas Chromatograph

Calibration and Quality Control Procedures

Bendix NO_x Analyzer	Calibration standards were prepared with known amounts of NO being injected into Tedlar bags filled with ultrapure air
Bendix Ozone Analyzer	An ozone generator was used to prepare Tedlar bags of known ozone concentration for calibration standards
Tracor Sulfur Analyzer	Known amounts of SO_2 were injected into Tedlar bags filled with ultrapure air and used as calibration standards
Perkin Elmer 900	Known amounts of C_1 - C_{10} hydrocarbons were injected into Tedlar bags filled with ultrapure air and used as calibration standards
Beckman 6800	A commercial calibration gas cylinder was used as the primary standard. For the secondary standard, known amounts of CH_4 and CO were injected into Tedlar bags filled with ultrapure air
General Quality Control	None of the above calibration gas mixtures were NBS traceable

Location and Type of Data Available

Because of sample contamination from the polyvinyl fluoride (Tedlar) bag material, the EPA Principal Investigators do not feel that the data should be included in the RAPS Data Bank. However, data in the form of strip charts, chromatograms, and logbooks may be obtained from William A. Lonneman, Principal Investigator.

Publication

Seila, R. L., W. A. Lonneman and S. A. Meeks. Evaluation of Polyvinyl Fluoride as a Container Material for Air Pollution Samples. Journal of Environmental Science and Health, Environmental Science and Engineering, A11 (2): 121-130, 1976.

7.2.3 BATTELLE-COLUMBUS SMOG CHAMBER STUDY

Principal Investigator

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Funding EPA Contract No. 68-02-1720

Period of Performance June 1976 - September 1977

Technical Approach

The purpose of the Smog Chamber Study was to determine the rate of conversion of SO_2 as a function of reactant concentration in ambient air. A 13.5 m^3 5 mil Teflon (or Tedlar) chamber was filled with ambient air, sealed off, exposed to direct sunlight, and monitored. It was assumed that the initial concentrations of pollutants in the ambient air were the same as those being measured by the RAMS station at which the chamber was set up. While the experiments were in progress, direct measurements of the chamber atmosphere were made for SO_2, NO, NO_x, O_3, aerosol size distributions, and sulfate aerosol by filtering. Control samples of ambient air in Teflon or Tedlar bags were also exposed to sunlight. After sunlight irradiation, the sample bags were chemically analyzed.

Periods of Data Collection

Samples were taken daily during the following periods:

RAMS Site 106	July 12-15, 1976
RAMS Site 103	July 19-30, 1976

Parameters Measured	Instrument/Method Used
Nitrous Oxide, Oxides of Nitrogen	Bendix Series 8100 NO_x Analyzer
Sulfur Dioxide	Beckman Model 906 Sulfur Dioxide Analyzer
Ozone	REM 612B Chemiluminescent Ozone Analyzer
Aerosol Concentrations	Thermo-Systems Model 3030 Electrical Aerosol Analyzer
Nitric Acid	Homemade Nitric Acid Analyzer
Time integrated particulate loadings	Sequential Air Filter Sampler

Calibration and Quality Control Procedures

Calibrations were performed before the start of each sampling period, and not on a daily basis.

Bendix NO_x Analyzer	The analyzer was calibrated against an NBS span bottle of NO gas
Beckman SO_2 Analyzer	Calibrated using Metronix permeation tube
REM O_3 Analyzer	Calibrated using the neutral buffer KI method
Thermo-System Aerosol Analyzer	Basic monodisperse calibration was performed
Battelle Nitric Acid Analyzer	Calibrated once before the study by expanding a known volume of pure nitric acid from a vacuum line into the smog chamber and analyzing with the Battelle nitric acid instrument. As a further check, the nitric acid content in the chamber was determined with a chemiluminescent analyzer, the Bendix 8100 Oxides of Nitrogen Analyzer

Calibration and Quality Control Procedures (continued)

Battelle Sequential Air Filter Sampler	The critical orifices were calibrated using a flow meter once before and once after the study and identical readings were obtained. The filter was in place during the calibrations

Location and Type of Data Available

Data, recorded on strip charts, magnetic tape, and in tabular form, may be obtained from the Principal Investigator.

Publication

Miller, D. F. Precursor Effects of SO_2 Oxidation. Atmospheric Environment, 12:273-280, 1978.

7.2.4 O_3 - NO - NO_2 MAXIMA STUDY

Principal Investigators

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Funding

Regional Air Pollution Study
Program Element 1AA003, Research Objective Achievement Plan 26AAI
Program Element 1AA603

Period of Performance July 1975 - August 1976

Summary

During the summer of 1975, five flights were made with instrumented helicopters to measure ozone and oxides of nitrogen in the St. Louis urban plume. Further flights in the same program were made during the summer of 1976. However, due to the uncertainty of navigational position, data from the 1976 flights remain unanalyzed.

The EPA/RAPS helicopters were instrumented to measure: Ozone (O_3), nitric oxide (NO), total oxides of nitrogen (NO_x), sulfur dioxide (SO_2), temperature, dew point, particulate light scattering, pressure altitude, air speed, compass heading, and navigational position. For further details on actual instruments used and the calibration of those instruments, see Section 5.0.

Throughout the helicopter flights, wind data were being obtained from RAPS Upper Air Sounding Network stations. Flight patterns for each experiment were planned taking into account the most recent forecast of wind speed and direction together with recent pibal measurements. Cross sections were determined by means of flights perpendicular to the wind direction. Flights were made until the outer boundaries of the urban plume were defined. When cross sections were completed, the aircraft returned to the position of the maximum ozone or NO concentration, and flights to determine the vertical distribution of pollutants were performed. Flight patterns are shown in Figure 7.

Period of Data Collection

Valid data were collected from July 15, 1975 through August 6, 1975. Locations of sampling are shown in Figure 7.

Location and Type of Data Available

All data have been recorded on magnetic tape for both 1975 and 1976 flights. However, only 1975 data have been reduced and analyzed, since navigational positions were uncertain for 1976 flights. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Hester, N. E., R. B. Evans, F. G. Johnson, and E. L. Martinez. Airborne Measurements of Primary and Secondary Pollutant Concentration in the St. Louis Urban Plume. In: Proceedings of the International Conference on Photochemical Oxidant Pollution and Its Control, Volume I, pp. 259-274. January 1977. EPA-600/3-77-001a.

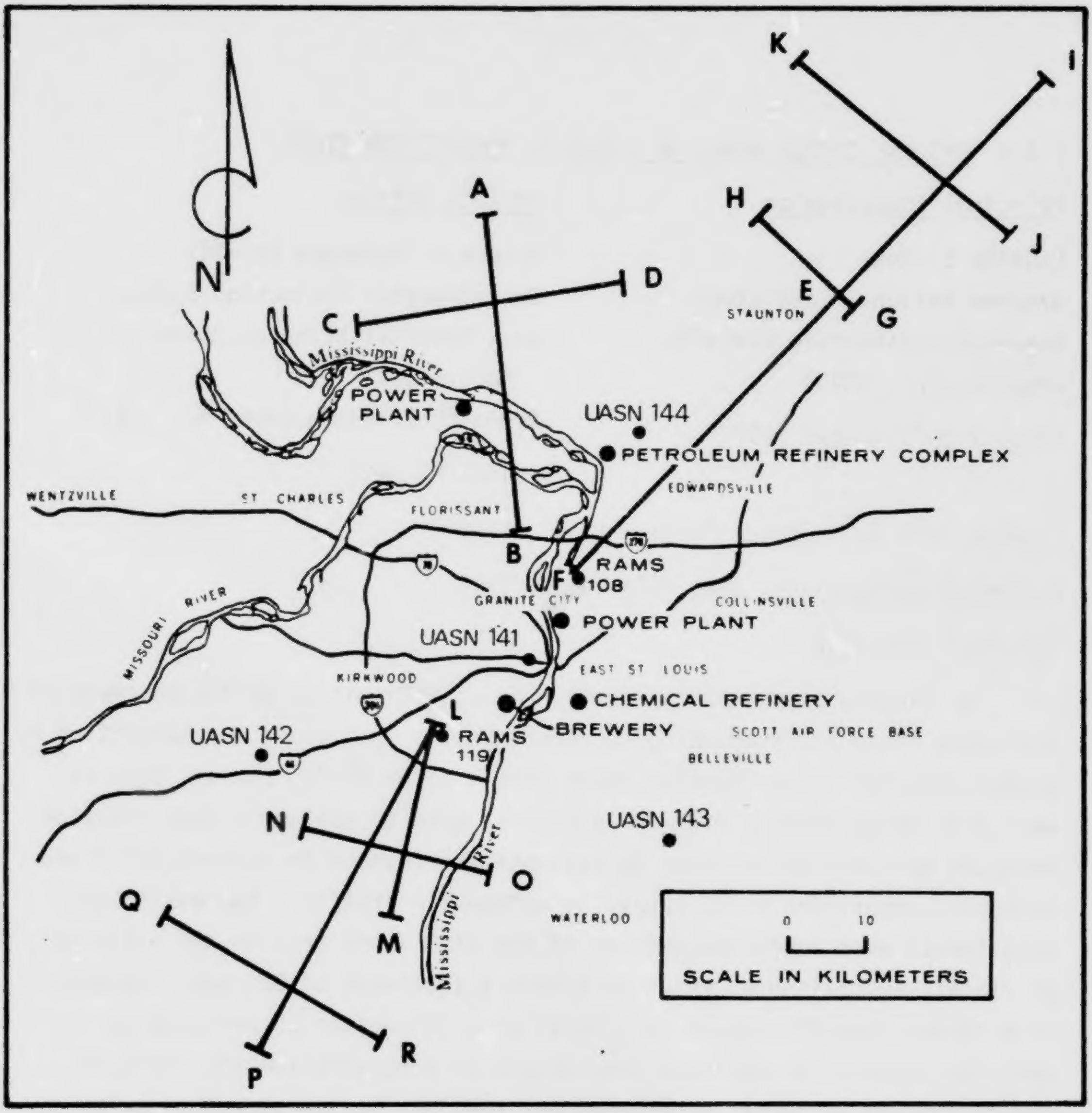

FIGURE 7. FLIGHT PATTERNS FOR O_3 - NO - NO_2 MAXIMA STUDY

7.2.5 ARGONNE CARBON MONOXIDE ISOTOPIC COMPOSITION STUDY

Principal Investigator	Project Officer
Laurids E. Ross Argonne National Laboratory Chemical Engineering Division Argonne, IL 60439 (312) 739-7711, ext. 2527	Joseph J. Bufalini (MD-84) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-2422

Funding EPA Interagency Agreement No. IAG-069

Period of Performance June 1973 - June 1974

Technical Approach

The purpose of the study was to provide information on the movement of the urban plume by determining the concentration and isotopic composition of carbon monoxide in air samples taken within 80 km of St. Louis. Samples were also taken along a highway in a rural area to monitor carbon monoxide produced by vehicles in order to evaluate the changes in concentration and isotopic composition of CO caused by automobile traffic. Two additional experiments were conducted outside of the RAPS study area in the vicinity of Plainfield, Illinois, which is situated southwest of Chicago. Samples were taken along Highway 55 in a rural area to monitor CO produced by vehicles in order to evaluate the changes in concentration and isotopic composition of CO caused by automobile traffic. In the second experiment, diurnal changes in concentration and isotopic ratios of CO in a predominantly agricultural area were determined.

Periods of Data Collection

June 27, 1973	Locations 1-5 (see Figure 8 for locations)

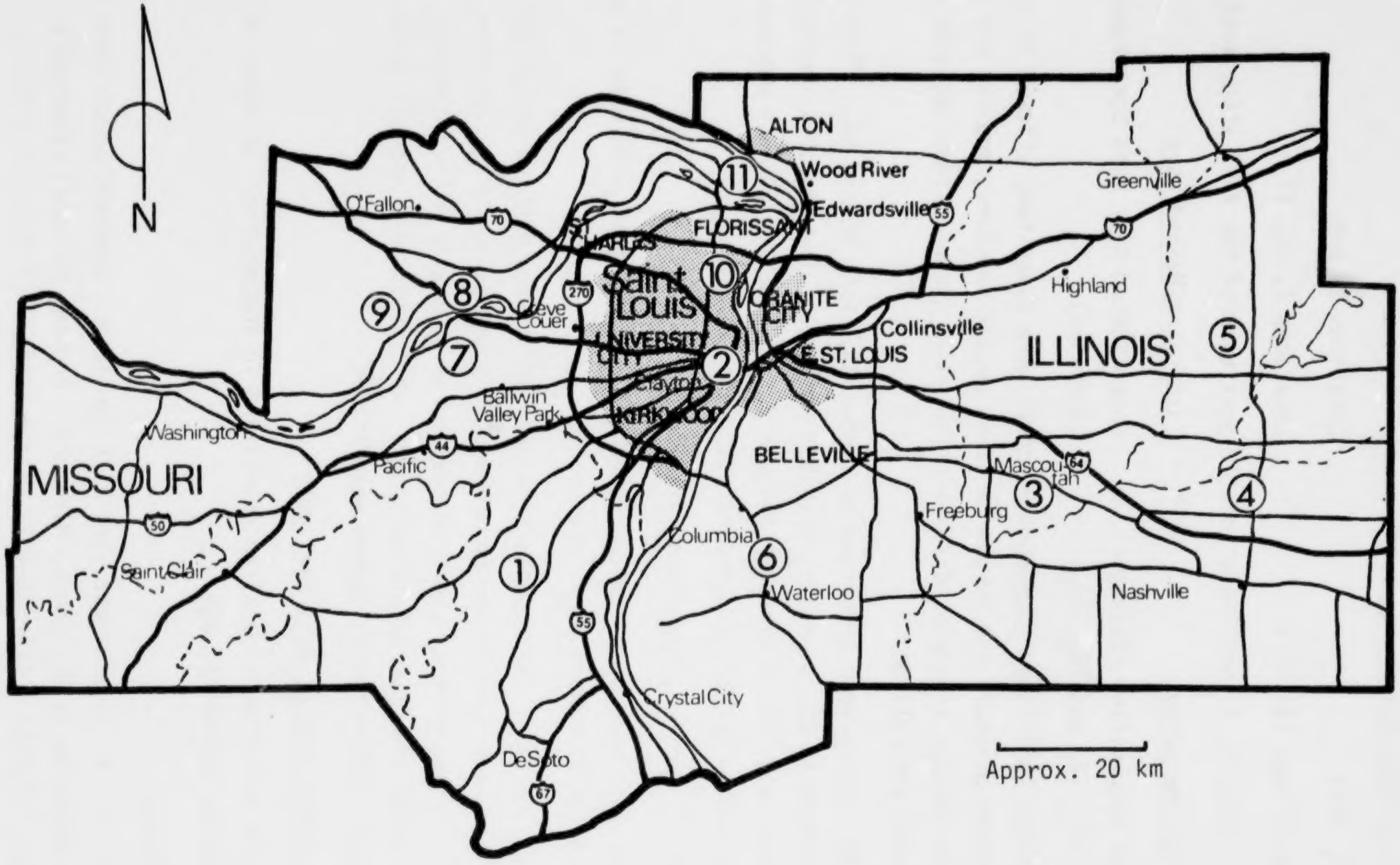

FIGURE 8. ARGONNE CARBON MONOXIDE ISOTOPIC COMPOSITION STUDY SITES

Periods of Data Collection (continued)

July 17, 1973	Locations 2, 6-9
November 13 and 14, 1973	Locations 1, 10, 11

(Note: Sites 3, 4, and 5 are located just east of the RAPS study area).

Parameters Measured	Instrument/Method Used
Isotopic composition (isotopic ratios $^{13}C:\ ^{12}C$ and $^{18}O:\ ^{16}O$)	Consolidated-Nier Mass Spectrometer (Modified)

Ninety (90) liter aluminum cylinders were evacuated, allowed to come to atmospheric pressure and pumped to 30-40 pounds pressure, ambient air being taken in through a sample port one meter above ground. Sampling time was 15 minutes per cylinder.

Air samples were processed to remove CO_2, N_2O, NO and NO_2. Then CO was oxidized to CO_2 with I_2O_5 (Schutze reagent). The CO_2 thus formed was liquified in a liquid nitrogen trap, and the amount of CO_2 was measured manometrically and the CO concentration was then derived.

Calibration and Quality Control Procedures

Standard mass spectrometric calibration procedures were used on the Consolidated-Nier mass spectrometer.

As a check on the results obtained, additional samples were taken in Tedlar bags and sent to the Environmental Sciences Research Laboratory at Research Triangle Park. Some of the Tedlar bags were filled directly from the 90 liter aluminum sample cylinders, while most were ambient samples taken just before the cylinders were filled.

Location and Type of Data Available

Data extracted from strip charts and in logbooks may be found in the publication referenced below.

Publication

Ross, L. E., A. Engelkemeir, and E. E. Voiland. Isotopic Composition of Carbon Monoxide in St. Louis, Missouri. Argonne National Laboratory, Argonne, Illinois. EPA-IAG-069. April 1976. EPA-600/3-76-010.

7.2.6 MIDWEST OXIDANT TRANSPORT STUDY

Introduction

The Midwest Oxidant Transport Study was conducted from July 8 to August 4, 1977 by investigators from Battelle-Columbus Laboratories, Washington State University (WSU), and EPA/ESRL. Ozone precursor relationships and causes of high rural ozone levels over several midwestern states were investigated. To aid this multistate study, instrumented aircraft were employed by both Battelle and WSU for extensive horizontal and vertical profile determinations. Flight patterns were designed to investigate three major areas: 1) downwind plumes from small urban areas (pop. 200,000 or less) to determine the magnitude of increased ozone levels above background; 2) vertical profiles for ozone and its precursors to altitudes of 20,000 feet to determine ozone concentrations above the subsidence inversion layer; and 3) background levels of ozone and its precursors in rural areas of the midwestern U.S. and the effect of the passage of high pressure systems on pollutant concentrations. EPA/ESRL, WSU and two Battelle mobile laboratories were set up as ground monitoring sites to analyze samples taken in the air and on the ground in plastic bags and aluminum cylinders.

The following three sections detail operations of the three groups of investigators.

7.2.6.1 BATTELLE INSTRUMENTED AIRCRAFT AND MOBILE LABORATORIES

Principal Investigator

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Research Triangle Park, NC 27711

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Funding EPA Contract No. 68-02-2439

Period of Performance June - August 1977

Periods of Data Collection

Battelle ground units #1 and #2, in operation for the entire study period (July 8 - August 4, 1977), were located at UASN site 144 at the Alton Civic Memorial Airport. The aircraft made fairly routine flights over the RAPS study area during this time.

Hard copy plots of flight paths have been generated and are available from the Principal Investigator.

Battelle Instrumented Aircraft

Parameters Measured	Instrument/Method Used
Ozone	Dasibi Airborne Ozone Analyzer
Ozone	REM 612B Chemiluminescent NO_x Analyzer
Ozone, Nitric Acid	TECO Model 14D Chemiluminescent NO_x Analyzer (modified to measure HNO_3)
Total Suspended Particulate	High Volume Sampler (Battelle's own design)
Air speed, altitude, temperature, relative humidity (also VOR and DME signals accepted)	Metrodata Data Logger System
Used for recording data on magnetic tape	Pertec Data System

Calibration and Quality Control Procedures

Dasibi Airborne Ozone Analyzer	Due to a malfunction, this instrument was used for only one week
REM NO_x Analyzer	Calibrated periodically using a MacMillan 1000 Ozone Generator which was itself calibrated before and after the study
TECO NO_x Analyzer	Calibrated with a permeation tube bi-weekly. Cross-calibrated against WSU instruments
Hi-Vol Sampler	Flow rate calibrated before and after study. Pressure drop checked several times daily
Metrodata System	Problems were experienced with the system since it was being used for the first time

Calibration and Quality Control Procedures (continued)

Pertec Data System	Problems were experienced with the system since it was also being used for the first time

Battelle Mobile Laboratories

Parameters Measured	Instrument/Method Used
Wind speed and direction, temperature and relative humidity	MRI Model 1071 Weather Station
Solar Intensity	Eppley 180° Pyrheliometer
Total Suspended Particulates	Two High Volume Samplers (Battelle's own design)
Used for collecting aerosol samples over long time intervals	Low Volume Sampler (Battelle's own design)
Ozone	Bendix Model 8002 Chemiluminescent Ozone Analyzer
Nitrous Oxide	Bendix Model 8101-B NO_x Analyzer
Nitrogen Dioxide	Bendix Model 8101-B NO_x Analyzer (modified)
Peroxyacetyl Nitrate (PAN)	Varian Hi-Fi III Electron Capture Gas Chromatograph
Nitric Acid	Mast Micro-Coulometric Ozone Analyzer (modified)
Fluorocarbon-11	Varian Hi-Fi III Electron Capture Gas Chromatograph
Total Hydrocarbons, Methane, Acetylene, Ethylene and Carbon Monoxide	Beckman Model 6800 Gas Chromatograph
Ammonia, Nitrate and Sulfates	Dionex Ion Chromatograph
Used for cassette tape data storage	Digitem Data Acquisition System

Calibration and Quality Control Procedures

MRI Meteorological Station	Relative humidity and temperature calibrations were performed biweekly
Eppley Pyrheliometer	No special calibrations for this study were performed. Normally the instrument is calibrated once or twice per year
Hi-Vol Samplers	Flow rate calibrated before and after study. Pressure drop checked several times daily
Bendix Ozone Analyzer	Calibrated biweekly using the MacMillan 1000 Ozone Generator
Bendix NO_x Analyzer	Calibrated biweekly with an NBS cylinder containing NO in N_2.
Bendix NO_x Analyzer (modified)	Calibrated biweekly with an NBS permeation tube
Mast Ozone Analyzer (modified)	Calibrated once before the study in a smog changer
Varian Gas Chromatograph (for PAN)	Calibrated prior to study in the laboratory by infrared spectral analysis. In the field, periodic cross-calibrations were performed against WSU instruments
Varian Gas Chromatograph (for Fluorocarbons)	A permeation tube was used during biweekly calibrations against standards prepared by WSU. Mass spectral analysis was performed before and after the study
Beckman 6800	Daily calibrations were performed using NBS traceable standard hydrocarbon mixtures and prepared hydrocarbon mixtures

Calibration and Quality Control Procedures (continued)

Dionex Ion Chromatograph	Checked two or three times daily for proper operation
Digitem Data System	The system worked satisfactorily and no special checks were made

Location and Type of Data Available

Data in the form of strip charts, cassette tapes, and 4-track magnetic tape cartridges, are still in the possession of the Principal Investigator who is in the process of data reduction and analysis. Upon completion, data will be incorporated into the RAPS Data Bank.

Publication

A report on The Fate of NO_x in the Atmosphere and the Transport of Oxidant beyond Urban Areas is to be published in August 1979.

7.2.6.2 WASHINGTON STATE INSTRUMENTED AIRCRAFT AND MOBILE LABORATORY

Principal Investigator

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Funding EPA Grant No. R805142

Period of Performance June - August 1977

Periods of Data Collection

The WSU mobile laboratory, operational for the entire study period (July 8 - August 4, 1977), was located in Robinson, Illinois. Although it was well outside the RAPS study area, samples were analyzed in the laboratory which were taken during five flights over the St. Louis area, from July 15 to July 30.

Hard copy plots of flight paths have been generated and are available from the Principal Investigator.

Washington State Instrumented Aircraft

Parameters Measured	Instrument/Method Used
Ozone	Bendix Model 8002 Ozone Analyzer
Oxides of Nitrogen	Monitor Labs Model 8440 Analyzer
Sulfur Dioxide	TECO Model 43 Pulsed Fluorescent Analyzer
Aerosol Loadings	Environment - 1 Condensation Nuclei Counter
Light Scattering Coefficient	MRI Integrating Nephelometer
Air speed, altitude, temperature, relative humidity (VOR and DME signals accepted also)	Metrodata M8 Data Logger System

Calibration and Quality Control Procedures

Bendix Ozone Analyzer	Calibrated weekly using MacMillan Ozone Generator. The final calibration after the study was NBS traceable. The neutral buffer KI technique was used for all calibrations
Monitor Labs Analyzer	Calibrated weekly with a standard cylinder of NO gas. Gas titrations were performed in the laboratory. The converter efficiency was checked in August 1977 by the State of Wisconsin
TECO Analyzer	Calibration was performed prior to beginning of study with a permeation tube (NBS traceable)
Environment - 1 Counter	Calibrated once before the start of the study. (Used only as a plume detector)
MRI Nephelometer	Calibrated once before the start of the study. (Used only as a plume detector)

Calibration and Quality Control Procedures (continued)

Metrodata M8 System	Temperature and relative humidity calibration curves were determined. The relative humidity sensor was changed weekly.

Washington State Mobile Laboratory

Parameters Measured	Instrument/Method Used
C_2 - C_{10} hydrocarbon	Perkin Elmer Model 900 Gas Chromatograph
Flourocarbon-11 and -113, Chloroform, Ethyl Chloroform, and Carbon Tetrachloride	Hewlett-Packard Electron Capture Gas Chromatograph
Used for 4-track magnetic tape cartridge storage of data	Metrodata 620 Data Logger

Calibration and Quality Control Procedures

Perkin Elmer 900	Standard mixture of C_2 - C_{10} hydrocarbons were prepared and used for daily calibrations
Hewlett-Packard Gas Chromatograph	Standard mixtures of halocarbons were prepared and used for daily calibrations for all halocarbons listed in "Parameters Measured"
Metrodata 620 Data Logger	No special checks were made on the system since it appeared to perform satisfactorily

Location and Type of Data Available

Data, in the form of strip charts and 4-track magnetic tape cartridges are in the possession of the Principal Investigator.

Publication

A final report on this study is expected to be published in August or September 1979.

7.2.6.3 EPA/ESRL MOBILE LABORATORY

Principal Investigators

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Environmental Protection Agency
Environmental Sciences Research Laboratory
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Funding Environmental Protection Agency

Period of Performance July - August 1977

Period of Data Collection

The EPA/ESRL Mobile Laboratory, located at RAMS Site 114 in north St. Louis County, was operational for the entire study period (July 8 - August 4, 1977).

Parameters Measured	Instrument/Method Used
C_2 - C_{10} Hydrocarbon Concentrations	Perkin Elmer Model 900 Gas Chromatograph and PEP-2 Computer System
Ozone	Bendix Model 8002 Chemiluminescent Ozone Analyzer
Freon-11	Perkin Elmer Model 3920 Electron Capture Gas Chromatograph
Peroxyacetylnitrate (PAN)	Analog Technology Corporation Electron Capture Detector
Total Hydrocarbons, Carbon Monoxide	Beckman Model 6800 Gas Chromatograph

Parameters Measured	Instrument/Method Used (continued)
Oxides of Nitrogen	TECO Model 14B Chemiluminescent NO_x Analyzer
Wind speed and direction	Bendix Aerovane System
Relative humidity, temperature	Belfort Hygrothermograph
Solar radiation (2900 - 4000 Å)	Eppley UV Radiometer

Calibration and Quality Control Procedures

Perkin Elmer 900 Chromatograph	Weekly calibrations were performed using a hydrocarbon mixture prepared at Research Triangle Park.
Bendix Ozone Analyzer	Periodic calibration was performed using an Ultraviolet Products Ozone Generator. An internal calibration was carried out every other day. The ozone generator was calibrated according to the neutral buffered KI method.
Perkin Elmer 3920	Calibrations were performed July 2 and August 1, 1977.
Analog Technology Detector	A Tedlar bag containing a known concentration of PAN was used for the calibrations which were performed July 2 and August 1, 1977.
Beckman 6800	Weekly calibrations were performed using a mixture of hydrocarbons and CO
TECO NO_x Analyzer	A cylinder of NO was used for periodic calibrations (NBS traceable)
Bendix Aerovane System	After initial set-up with a compass, no further calibrations were carried out

Calibration and Quality Control Procedures (continued)

Belfort Hygrothermograph	One calibration prior to beginning of study was performed
Eppley UV Radiometer	No special calibration for the study was performed. The instrument is calibrated by Eppley yearly, prior to field studies

Location and Type of Data Available

Data, in the form of strip charts and computer printouts of pollutant concentrations at five minute intervals, are still in the possession of the Principal Investigators who are in the process of data reduction and analysis. The data will be available through the RAPS Data Bank. For information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

A final report on this study is expected to be published in August or September 1979.

7.3 AEROSOL CHARACTERIZATION STUDIES

7.3.1 AEROSOL SOURCE CHARACTERIZATION

7.3.1.1 EPA/ESRL AEROSOL LABORATORY TRAILER

Principal Investigator	Project Officer
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Funding

EPA Contract No. 68-02-1081, Task Order No. 19
Regional Air Pollution Study, Program Element 1AA003,
Research Objective Achievement Plan 26AAI
MISST Funding 1NE625

Period of Performance September 1973 - August 1976

Technical Approach

Aerosol source characterization studies, carried out intermittently over a 4 year period, investigated the existence, transport and removal of aerosols in the RAPS area. During the period, the EPA/ESRL Aerosol Lab Trailer was at the following locations (Figure 9):

Summer 1973 - Washington University Campus
Spring 1974 - Washington University Campus
Summer 1974 - RAMS Site 103
Summer 1975 - Glasgow, Illinois (100 km north of St. Louis)
Summer 1976 - Spirit of St. Louis Airport

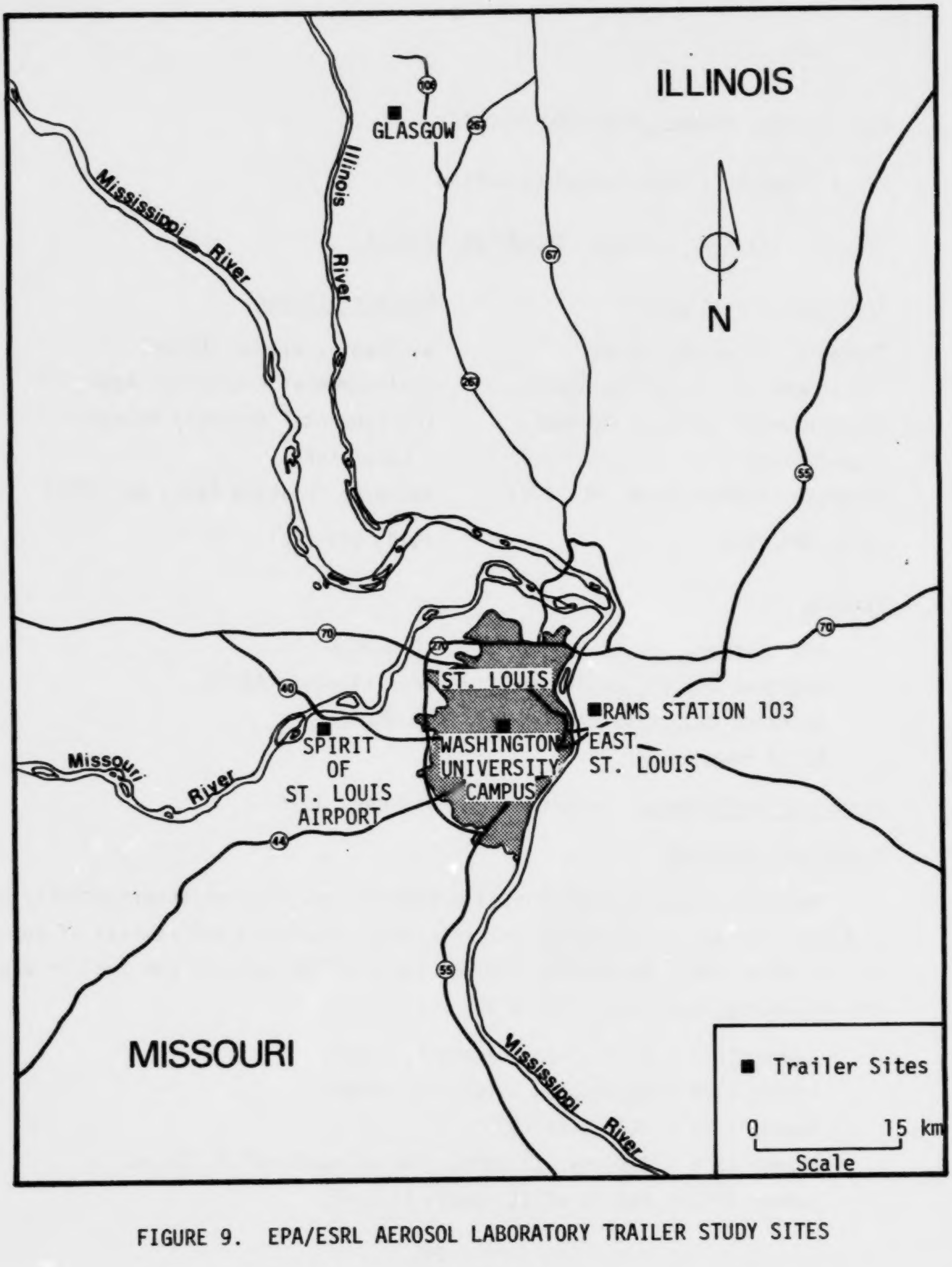

FIGURE 9. EPA/ESRL AEROSOL LABORATORY TRAILER STUDY SITES

The Lab Trailer was instrumented to measure both gaseous and particulate contaminants as well as various surface meteorological parameters. The trailer also provided the ground support data for correlation with instrumented aircraft flights. (Sections 7.1.1.1, 7.1.1.2, and 7.3.1.2.)

Periods of Data Collection

September 5 - October 9, 1973
March 1-2, 1974
August 5 - August 27, 1974
July 15 - August 15, 1975
July 9 - August 15, 1976

Parameters Measured	Instrument/Method Used
Sulfur Dioxide	Meloy Model SA-160 flame photometric detector with a minimum detection limit of 0.005 ppm and a Meloy SA-185 flame photometric detector. Minimum detection limit was 15 ppb.
Oxides of Nitrogen	Thermo Electron Corporation (TECO) 14-B NO/NO_2 chemiluminescent analyzer with a minimum detection limit of 1 ppb.
Ozone	Bendix Model 8100 chemiluminescent ozone analyzer with a minimum detectable limit of 1 ppb.
Total Hydrocarbons, Carbon Monoxide and Methane	Beckman Model 6800 Air Quality Chromatograph utilizing a flame ionization detector. The lower detection limit was 0.2 ppm for CO and 0.05 ppm for THC and CH_4.
Particle size distribution	Whitby Electric Aerosol Analyzer and Royco Models 220 and 245 optical particle size analyzers. These instruments covered the particle size ranges between .01μ to 40μ.

Parameters Measured	Instrument/Method Used (continued)
Light scattering coefficient	Meteorology Research, Inc. (MRI) Model 1550 nephelometer. Sensitivity range was from 10^{-5} to 10^{-2} reciprocal meters.
Condensation Nuclei	Environment/One Rich-100 Condensation Nuclei Counter
Particulate Composition and Mass loadings	A variety of instruments were used to collect particle data. High volume filter samplers were used to measure total suspended particulate while an Anderson impactor, LBL dichotomous sampler and Jensen Nelson streakers were used to collect samples for subsequent X-ray analysis.
Solar Radiation	Two Eppley radiometers measuring both broadband and ultraviolet radiation.
Barometric Pressure	Rosemount pressure sensor.
Relative Humidity	EG&G Vapormate II dew point sensor.
Wind Speed, Wind Direction and Ambient Temperature	Climet meteorological system.

Calibration and Quality Control Procedures

Calibrations were not adequate for '73 and '74 and no valid data are available. In 1974, NBS permeation tubes were used for SO_2 calibrations and NBS traceable permeation tubes for NO. Ozone was determined by NO titration, and a certified Scott cylinder was used for hydrocarbon calibrations. Five point calibrations were performed before each sampling period.

Location and Type of Data Available

All data were either recorded or placed on magnetic tape. The 1973 period was used primarily to set up and check out the instruments, and no valid data were produced. During 1974 and 1975, data for both gaseous and particulate pollutants were gathered, but only 1975 gaseous data are reliable. Data on gas analyses are being processed at the Environmental Research Laboratory at Research Triangle Park.

Particle size data are being processed by Dr. Whitby at the University of Minnesota.

Valid data were also produced during the 1976 period and were audited by an independent quality assurance team.

For additional information or to inquire about data availability contact the EPA Principal Investigator.

Publication

Wang, H. H. Support for the EPA Aerosol Laboratory. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 19 Final Report, EPA Contract 68-02-1081. April 1974.

7.3.1.2 AIRCRAFT MONITORING SUPPORT

Principal Investigator	Task Coordinator
C. Shepherd Burton (formerly with) Rockwell International Air Monitoring Center 11640 Administration Drive Creve Coeur, MO 63141	William E. Wilson (MD-84) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711
(314) 567-6722	(919) 541-2551

Funding EPA Contract No. 68-02-1081, Task Order No. 6

Period of Performance July - November 1973

Technical Approach

Meteorology Research, Inc. (MRI) provided the aircraft monitoring support for an aerosol characterization study undertaken in St. Louis over a 9-day period from September 1 to September 9, 1973.

MRI's primary objective during the field test was to demonstrate the feasibility of using a fixed-wing, single-engine aircraft (instrumented for air pollution sampling) in upcoming St. Louis studies (Section 7.1.1.1 and 7.1.1.2). The successful completion of a wide variety of flight patterns and special sampling requirements clearly demonstrated the achievement of this goal. Other objectives that were realized include the characterizations of both the St. Louis urban plume and Labadie power plant plume at various downwind distances from their sources. Preliminary information concerning particle growth rates was obtained for the Labadie plume as well as sulfate filter data. Finally, one flight was made to obtain three-dimensional urban aerosol mapping data. Further, it was shown that special particle sensors and filter sampling techniques could be adapted to the aircraft sampling package to provide additional aerosol data.

Period of Data Collection

Valid sampling flights were conducted on September 5, 6 and 7, 1973. The Metrodata logger recorded instantaneous values from 20 channels at 48 channels per second.

Parameters Measured	Instrument/Method Used
Ozone	REM 612 Ozone Monitor operated in an 0 - 0.5 ppm range with 5 second response time.
Oxides of Nitrogen	REM 642 $NO\text{-}NO_X$ Monitor operated in the 0 - 0.5 ppm range with 15 second response time.
Carbon Monoxide	Andros Model 7000 CO Monitor operated in the 0 - 50 ppm range with a specially ordered 5 second response time.
Light Scattering Coefficient	MRI Integrating Nephelometer, 0 - 10×10^{-4} m^{-1} range with a 1 second response time.
Condensation Nuclei	Environment 1 Condensation Nuclei Monitor (Rich 100), 0 - 15^5 cn/cc range. Response time was 5 seconds.
Temperature, Humidity, Turbulence, Altitude	MRI Airborne Instrument Package with the following response times: temperature - 15 seconds (thermistor) humidity - 30 seconds (strain gauge and cellulose element) turbulence - 10 seconds (Pitot-static tube) altitude - 1 second

The above instrumentation was interfaced to a Metrodata #620 data logger with 20 channel capacity. The position instrumentation in the aircraft used the standard aircraft VOR and DME systems interfaced to a Metrodata M/8 package to convert the signals to an analog output. Altitude was measured by a Validyne P-24 15 psi absolute pressure sensor which was part of the MRI Airborne Instrument Package.

Calibration and Quality Control Procedures

The instruments were zeroed and spanned before each flight. A calibration using zero and span gases was routinely performed once a month on these instruments. No other QC procedures were observed for this test period.

Location and Type of Data Available

Data from the aircraft flights are contained in the final report as computer generated profiles. The NO_X monitor was run during the flights, but an intermittent instrument failure resulted in the loss of almost all NO_X data. Therefore, the NO_X data obtained while the instrument was running are questionable and have not been included in the report. All aircraft data were recorded on tape cartridges and transferred to two magnetic tapes. One tape contains all vertical spiral data, while the other contains all horizontal traverse data.

The tapes were turned over to Dr. R. Husar at Washington University for analyses. Additional information on data availability may be obtained from:

Rudolph B. Husar
Air Pollution Research Laboratory
Mechanical Engineering Department
Washington University
St. Louis, MO 63130

(314) 889-6099

Publication

Anderson, J. A., and D. L. Blumenthal. Aircraft Monitoring Support for the Aerosol Characterization Study in St. Louis. Meteorology Research, Inc., Altadena, California. Task Order No. 6 Final Report, EPA Contract 68-02-1081. January 1974.

7.3.1.3 METEOROLOGICAL SUPPORT AND ANALYSIS

Principal Investigator

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Task Coordinator

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Environmental Protection Agency
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Funding EPA Contract No. 68-02-1081, Task Order No. 7

Period of Performance September - October 1973

Technical Approach

The purpose of this study was to provide meteorological support for the RAPS Aerosol Characterization Study; to outline analysis procedures applied to the data; to make certain recommendations, based on information gathered to date, relating to further analysis of the influence of the St. Louis urban build-up on localized circulation; and to determine the impact such a study may have on future field experiment planning and RAPS transport/trajectory model specification.

Environmental Quality Research's (EQR) meteorological support was basically twofold, aside from preparation of routine planning forecasts. One function was the real-time monitoring and interpretation of urban and mesoscale circulation patterns for pre-flight briefing for the Meteorological Research, Inc. (MRI) aircraft (Section 7.3.1.2). A second activity centered on the integration of various data records into a unified picture of the time evolution of those urban-scale circulation features affecting boundary layer air parcel trajectories.

Periods of Data Collection

Data were compiled from the following three sampling periods in 1973:

First Sampling Period: 1500 CST September 5 to
0700 CST September 7

Second Sampling Period: 1200 CST September 18 to
2300 CST September 20

Third Sampling Period: 1500 CST October 3 to
1300 CST October 4

Pibals were launched at Washington University at approximately two-hour intervals during the daylight and early evening hours.

Radiosondes were launched at the St. Louis Gateway Arch at 0600 and 1200 CST.

Parameters Measured	Instrument/Method Used
Surface Temperature, Wind Speed and Direction	Surface data were derived from the 10-station remote telemetry air quality monitoring network operated jointly by the St. Louis Air Pollution Office and the St. Louis County Health Department. Refer to Section 10.2 for specific information regarding the network's instrumentation.
Wind Speed and Direction Aloft	Release of a 10 gram pilot balloon (pibal) tracked by a single theodolite to a maximum altitude of about 1 km. Pibals released at approximately two-hour intervals during the daylight and early evening hours, with angular readings taken every 30 seconds for a ten minute duration. Elevation and azimuth

Parameters Measured	Instrument/Method Used (continued)
	angles were field reduced to wind speed and direction utilizing a National Weather Service (NWS) winds aloft plotting board and employing the one minute overlap wind reduction technique. Wind direction was reported in degrees azimuth with reference to true north and wind speed in meters per second.
Temperature, Relative Humidity, Pressure, Wind Speed and Direction Aloft	Viz 403 MHz Model No. 1395 radiosonde equipped with a standard thermistor, hygristor and baroswitch. The unit was tracked by a single theodolite, with angular readings of elevation and azimuth taken every 30 seconds. Data were transcribed to a D-31 adiabatic chart and manually reduced to temperature and dew point in degrees Celsius, barometric pressure in millibars, wind direction in degrees azimuth with respect to true north and wind speed in meters per second.

The radiosonde was carried aloft by a 100-gram balloon at a reduced ascent rate, obtaining an altitude of 700 mb in 20 minutes. Radiosondes were tracked to 700 mb (approximately 3 km) whenever possible. Altitude was calculated in meters above mean sea level. Significant levels were selected whenever the temperature deviated ± 1.0°C from the established lapse rate and whenever the relative humidity deviated 10% or more from the established trend.

Location and Type of Data Available

All meteorological support analyses and abbreviated data records are contained in the final report referenced below. Radiosonde data may be obtained from the RAPS Data Bank. For information contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Dannevik, W. P., S. P. Frisella, and H. J. Hwang. Analysis and Interpretation of Meteorological Data in Support of the EPA/RAPS Aerosol Characterization Study, St. Louis, Missouri. Environmental Quality Research, St. Louis, Missouri. Task Order No. 7 Final Report, EPA Contract 68-02-1081. August 1974.

7.3.2 PARTICULATE MEASUREMENT AND ANALYSIS

7.3.2.1 FLORIDA STATE JENSEN NELSON STREAKERS

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Funding

Sample Collection

EPA Contract No. 68-02-1081, Task Order Nos. 35, 62
EPA Contract No. 68-02-2093, Task Order Nos. 117, 102

Sample Analysis

EPA Grant Nos. R-802132, R-803887, R-802913

Periods of Performance

Task Order No. 35	July - September 1974
Task Order No. 62	June - August 1975
Task Order No. 117	July - November 1976
Task Order No. 102	December 1976 - April 1977

Periods of Performance (continued)

R-802132 R-803887 R-802913	Analyses under these grants were performed after each period of data collection listed below.

Technical Approach

Over the period 1974-1976 a series of aerosol characterization studies utilizing Nelson Streaker samplers were conducted as part of RAPS. The Nelson Streaker is a time sequenced sampler which collects particulate matter on a Nucleopore filter in the form of a trace for up to eighty days. Nelson Streaker samplers were installed at the following RAMS sites at the 10 m level on the station towers:

Task Order No. 35 - 102, 103, 106, 108-110, 112-125 (106 and 103 had additional samplers at 20 and 30 m levels)

Task Order No. 62 - 101-125 (103 had an additional sampler at 28 m level)

Task Order No. 117 - 120, 124

Task Order No. 102 - 120, 124 (125 replaced 124 after February 15, 1977)

Periods of Data Collection

Task Order No. 35	July 28 - August 31, 1974
Task Order No. 62	July 14 - August 15, 1975
Task Order No. 117	July 1 - November 30, 1976
Task Order No. 102	November 30, 1976 - April 8, 1977

For each week of sampling, there were 84 individual time steps corresponding to the sequential operation of the streaker. Thus, aerosol compostional variations could be determined with two hour time resolution.

Parameters Measured	Instrument/Method Used
Aerosol composition, with elemental analysis including the elements sulfur, cerium, potassium, calcium, titanium, vanadium, chromium, manganese, iron, nickel,	Nelson Streaker Sampler, with an air flow rate of 2 liters per minute maintained. Elemental analysis of the collected particulate matter was by PIXE (Proton Induced X-ray Emissions).

Parameters Measured

copper, zinc, bromine and lead

Instrument/Method Used (continued)

An automated step drive sample handling device was used with a Van de Graaf accelerator to produce 5 MeV protons. X-ray counting was performed with a Si(Li) detector.

Calibration and Quality Control Procedures

As each sampler system was installed, a leak test was performed on the vacuum line, a new filter was installed, and the flow rate was measured and recorded. Seven days following the beginning of operation for each sampler system, the site was visited, the system inspected, and air flow measurements were made and recorded before the filter was removed. A new filter was then installed, and the air flow measured and recorded. This procedure was repeated every seven days of operation.

Location and Type of Data Available

Data will be available through the RAPS Data Bank. For information on data availability contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Jones, A. C. Support EPA-Aerosol Movable Semi-Trailer Summer 74. Rockwell International Science Center, Thousand Oaks, California. Task Order No. 35 Final Report, EPA Contract 68-02-1081. October 1974.

Jones, A. C. Summer 1975 Nelson Streaker Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 62 Final Report, EPA Contract 68-02-1081. December 1975.

No final report was required for Task Order No. 117.

Nelson, E. O. LBL Dichotomous Aerosol Filter Sampling System. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 102 Final Report, EPA Contract 68-02-2093. April 1979. EPA-600/4-79-024.

Pilotte, J. O., J. W. Nelson, and J. W. Winchester. Application of Multi-Station Time Sequence Aerosol Sampling and Proton Induced X-Ray Emission Analysis Techniques to the St. Louis Regional Air Pollution Study for Investigating Sulfur-Trace Metal Relationships. In : Proceedings of ERDA Symposium of X- and Gamma- Ray Sources and Applications, Ann Arbor, Michigan, 1976.

Winchester, J. W., and J. W. Nelson. Sources and Transport of Trace Metals in Urban Aerosols. Florida State University, Tallahassee, Florida. EPA Grant R802132. March 1979. EPA-600/2-79-019.

7.3.2.2 FLORIDA STATE IMPACTORS

Principal Investigator	Project Officer
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Funding EPA Grant Nos. R-802132, R-803913, R-803887

Period of Performance August 1973 - February 1974

Technical Approach

In August 1973 and February 1974 a team of scientists from EPA and Florida State University (FSU) conducted a field program in the St. Louis area in which aerosol and trace gas measurements were made in conjunction with meteorological observations. Investigators from FSU carried out sampling of the aerosol which was later followed by elemental analysis at FSU, the objective of which was to relate the time and particle size variations to aerosol sources and transport process. See Figure 10 for sampling locations.

Periods of Data Collection

Samples were collected at the following locations and times during August 1973 and February 1974:

1.	Broadway & Hurck Streets 15 m above street level	August 16 - 21, 1973 February 18 - 25, 1974

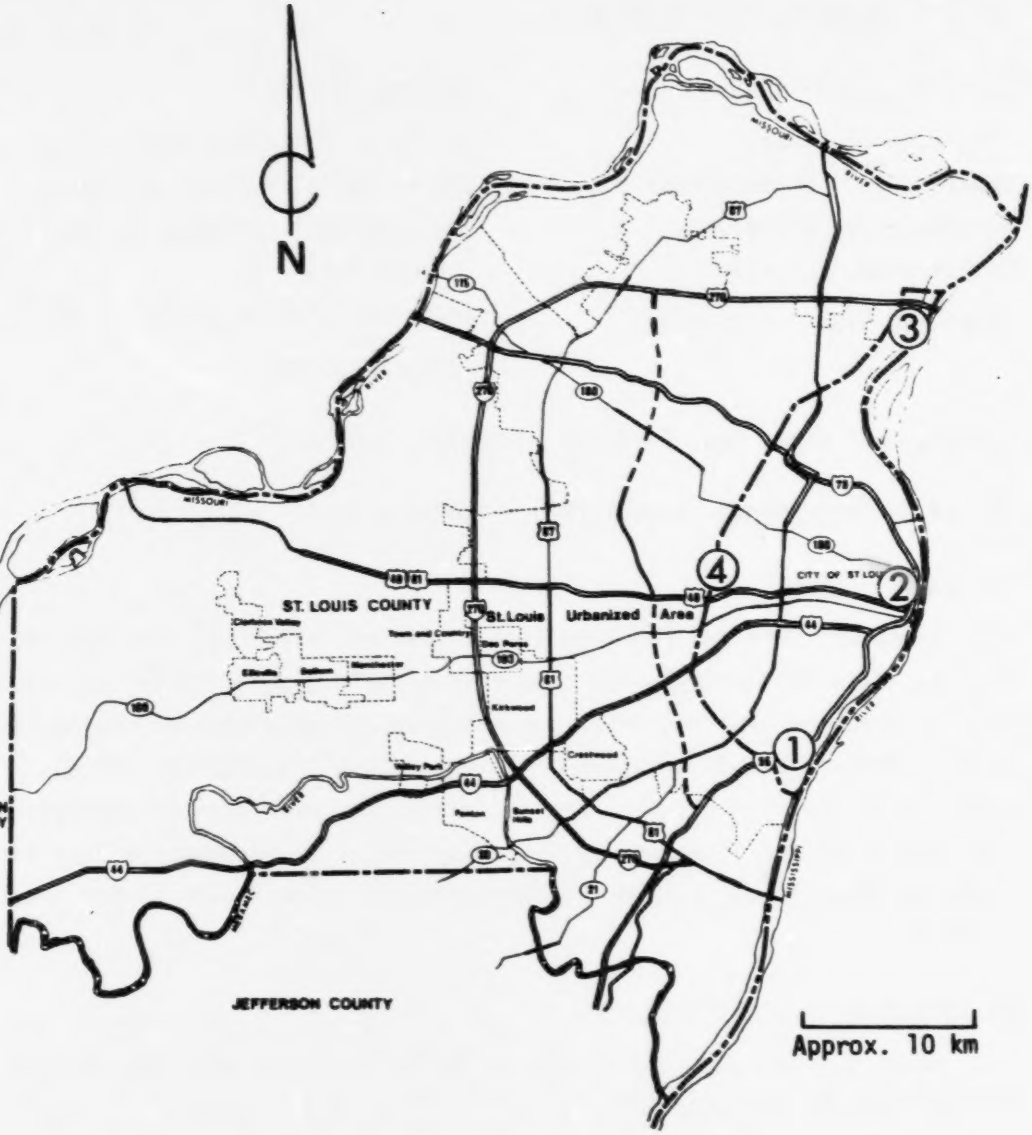

FIGURE 10. FLORIDA STATE IMPACTOR SAMPLING SITES

Periods of Data Collection (continued)

2. Holiday Inn Downtown — August 17 - 22, 1973
   50 m above street level
3. Head House, Chain of Rocks — August 25 - 28, 1973
   Municipal Water Co., St. Louis
4. Washington University — February 18 - 25, 1974

Parameters Measured	Instrument/Method Used
Elements for which reasonable accurate analyses (± 20% or better) were obtained included: Sulfur, Potassium, Calcium, Titanium, Iron, Zinc and Lead.	Two Battelle Cascade Impactors with five single orifice stages and a backup Nuclepore filter of 0.4 μm pore diameter were operated at a flow rate of one liter/min., controlled by a stage 5 as limiting orifice. All analyses were carried out by proton-induced x-ray emission using a 3.7 Me V proton beam of the FSU Tandem Van de Graaff Accelerator. This procedure was employed to give resolution of the aerosol into six particle size ranges. Successive stages of the impactor collected particles with effective diameters of >4μm, >2μm, >1μm, >0.5μm, >0.25μm, <0.25μm. Impaction surfaces consisted of a polystyrene film coated with a layer of evaporated paraffin and supported by 2.5 cm glass disk. Sampling time was approximately 12 hours.

Calibration and Quality Control Procedures

Battelle Cascade Impactor - Flow rates were checked before and after each 12 hour sampling period with a rotameter to detect any drift that might have occurred. The rotameter was calibrated in the laboratory using a wet test meter.

Calibration and Quality Control Procedures (continued)

Analytical Quality Control - Accuracy was achieved by maintenance of calibrated and reproducible bombardment conditions and by computer resolution of the x-ray spectra. Contamination was controlled in the laboratory by carrying out all operations on a clean workbench in a filtered-air environment.

Location and Type of Data Available

Data consist of detailed elemental analysis in tabular form. Although no single report or paper published to date contains all the data, the grant report cited below contains analyses of the data. For further information, contact the EPA Project Officer.

Publications

Orsini, C. Q., H. C. Kaufmann, K. R. Akselsson, J. W. Winchester and J. W. Nelson. Variation of Elemental Composition with Particle Size in the St. Louis Aerosol. Nuclear Instruments and Methods, 142 : 91-96, 1977.

Pilotte, J. O., J. W. Winchester, and J. W. Nelson. Components of Lead in the Atmosphere in St. Louis, Missouri. Journal of Applied Meteorology, 17:627-635, 1978.

Winchester, J. W. and J. W. Nelson. Sources and Transport of Trace Metals in Urban Aerosols. Florida State University, Tallahassee, Florida. EPA Grant R 802132. March 1979. EPA-600/2-79-019.

7.3.3 HIGH VOLUME FILTER SAMPLING NETWORK

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Task Coordinator

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Funding

EPA Contract No. 68-02-1081, Task Order Nos. 49, 51
EPA Contract No. 68-02-2093, Task Order No. 101

Periods of Performance

Task Order No. 49	August - September 1974
Task Order No. 51	January - August 1975
Task Order No. 101	August 1975 - May 1977

Technical Approach

High volume air samplers have been in use for many years for the collection of suspended particulate matter and are the EPA reference method. For this reason 10 RAMS stations were equipped with high volume samplers. During the study period, a total of 2,358 filter samples were collected and transported to a chemical laboratory (Rockwell International Air Monitoring Center at Newbury Park) where total suspended particulates (TSP) were determined and wet chemical analyses performed for sulfates ($SO_4^=$) and nitrates (NO_3^-). The data capture ratio was 96%.

Twin high volume samplers were installed at the following RAMS Sites: 103, 105, 106, 108, 112, 115, 118, 120, 122, and 124. The samplers were equipped with constant flow controllers to ensure a constant air flow through the filter regardless of filter loading within limits of the sampler's capabilities. However, this constant flow section was not connected during the first year of operation. After connection, the percentage of recoverable valid data vastly increased.

The concentration data for the three parameters studied appeared to vary both seasonally and between stations. The annual mean for each parameter was computed and plotted for each sampling station. The geometric mean ranged from 33.0 to 90.9 micrograms meter $^{-3}$ for TSP, from 7.0 to 12.7 micrograms meter^{-3} for $SO_4^=$, and from 2.3 to 3.8 micrograms meter $^{-3}$ for NO_3^-. Each year was divided also into quarters for each sampling station and the quarterly mean computed and plotted. The one way analysis of variance (ANOVA) technique was used to test the significance of the variations in concentration. The results of the ANOVA did indeed show a statistically significant difference in concentrations between stations and also between quarters or seasons of the year.

Periods of Data Collection

Ten samples were collected each sampling day (0000-2400 CST) during the following periods:

August - September 1974	Daily Samples
March 1975 - March 1977	Samples every third day

Parameters Measured	Instrument/Method Used
Total Suspended Particulates, Sulfates and Nitrates	Sierra 305 High Volume Sampler equipped with the Sierra 310B solid state constant flow controller. The model 310B had a range of 0.425 to 1.56 standard cubic meters-per-minute (m^3/min STP) and a 0 to 5 vdc output voltage proportional to flow rate (m^3/min STP). The constant flow controller used a constant temperature anemometer mounted

Parameters Measured

Instrument/Method Used (continued)

in the throat of the filter holder to control the flow rate through the sampler at a constant value measured in units of m^3/min (STP), independent of line voltage variation, ambient pressure, ambient temperature and filter loading.

Total Suspended Particulates (TSP) were determined gravimetrically by weighing the filters before and after collection on a Mettler H-20 balance to the nearest milligram.

Water soluble sulfate and nitrate were determined by extracting a 19 x 200 mm strip, cut from the center of the exposed filter, with boiling water. The filtered solution was analyzed using a Technican Auto Analyzer II. The methyl thymol blue method was used for sulfate. For nitrate analyses, the solution was reduced to nitrite by a copperized cadmium reductor column and reacted with a sulfanilimide. The resulting diazo compound was coupled with N-1-naphtyl ethylene diamine and determined colorimetrically.

Calibration and Quality Assurance Procedures

Each hi-vol sampler was calibrated using a 10 point calibration. The output voltage for the appropriate flow rate was noted and routinely checked each time a filter was placed in the sampler. If it varied more than ± 5% from the original value, the sampler was re-calibrated.

Each filter was individually inspected, numbered, and weighed before and

Calibration and Quality Assurance Procedures (continued)

after each sampling period utilizing the Community Health Air Monitoring Program (CHAMP) procedures. Filters were stored in a controlled environment. Quality assurance checks for mass determination were done on 10% of the filters. The Technicon Auto Analyzer was calibrated against standard solutions. Four control samples were used during each run, including a blank, a standard solution, and a duplicate strip.

As part of the QA program, unknown samples supplied by the Quality Assurance Branch at Research Triangle Park were analyzed at weekly intervals. In general, precision of the analyses as measured by the coefficient of variation, ranged from 1% to 6%.

Location and Type of Data Available

The High Volume Sampler data including the concentration of sulfates and nitrates, total suspended particulates and total air flow are available on *SAROAD nine-track, 800 BPI, odd parity tapes. These tapes contain no header records and the data files are terminated with five EOF's. The tape blocking is ten card images (80 ASCII characters/card) per physical record. Therefore, the record length is 800 bytes. The data produced will become part of the aerometric data base of the Regional Air Pollution Study. Further information on data availability may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Nelson, E. O. High Volume Filter Measurements of Suspended Particulate Matter. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 101 Final Report, EPA Contract 78-02-2093. Janauary 1979. EPA-600/4-79-003.

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*Daily Data Format

7.3.4 LAWRENCE BERKELEY LABORATORY (LBL) DICHOTOMOUS SAMPLERS

7.3.4.1 LBL DICHOTOMOUS SAMPLING NETWORK

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Funding

EPA Contract No. 68-02-1081, Task Order No. 27
EPA Contract No. 68-02-2093, Task Order No. 102

Periods of Performance

Task Order No. 27	January - August 1975
Task Order No. 102	September 1975 - April 1977

Summary

In support of the RAPS aerosol modeling studies, a network of ten LBL Automatic Dichotomous Air Samplers was installed and operated in the Regional Air Monitoring System (RAMS) by the Rockwell International Air Monitoring Center. Mass measurements and analyses of the samples were performed by the Lawrence Berkeley Laboratory (LBL), University of California under a separate contract with the EPA, details of which are discussed in Section 7.3.4.2.

The total number of filters collected was 33,695 not including 934 filter failures. Overall sampling efficiency was 97.25%. Sampler malfunctions accounted for a 0.67% failure rate, overload failures 0.37%, and miscellaneous causes 1.73%. It appears that the virtual impactor, with its inherent advantages, has fulfilled the need for an instrument to collect aerosols in two distinct size ranges.

The samplers were originally calibrated at Berkeley. After shipment to St. Louis, their calibration was re-checked and no variance from the original calibration was found. A routine flow check was made every time the samplers were loaded or cleaned.

The RAMS data acquisition and control system was used for surveillance of the sampling network to detect sampler malfunction. A computer operator prepared a check list three times daily indicating the operating condition of each sampler. This list indicated whether a sampler had failed or was operating normally. A master check sheet was kept at the main office indicating the operating condition of each sampler, the number of the slide tray and the estimated slide position, valid and invalid slides, and cause of invalidation. The information contained in the master check sheet was obtained from check sheets filled out when each site was visited, and a visual inspection was made by the visiting personnel. When these check sheets were returned, they were verified and the data recorded on the master check sheet.

The 10 LBL samplers were operated continuously from March 1975 to March 1977 at RAMS Sites 103, 105, 106, 108, 112, 115, 118, 120, 122 and 124.

The normal sampling periods were six hours for Sites 103 and 105, and twelve hours for the remaining sites. However, during the 1975 summer intensive study (mid July to mid August), sampling periods were reduced to two hours for Sites 103, 105, and 112 and six hours for the remaining sites to improve the time resolution of the monitoring network.

Additional information on sample collection may be obtained from the EPA Task Coordinator.

Publication

Nelson, E. O. Dichotomous Aerosol Sampling System. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 102 Final Report, EPA Contract 68-02-2093. April 1979. EPA-600/4-79-024.

7.3.4.2 LBL DICHOTOMOUS SAMPLE ANALYSES

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Funding EPA Interagency Agreements Nos. IAG-D6-0670, IAG-D6-0377

Period of Performance March 1975 - March 1977

Technical Approach

This section discusses the analyses conducted by the Lawrence Berkeley Laboratory of filters collected from the network of 10 LBL Automatic Dichotomous Samplers installed at 10 RAMS sites. The installation, operation, and maintenance of the samplers was the responsibility of Rockwell International Air Monitoring Center as previously outlined in Section 7.3.4.1.

Each sampler collected size segregated airborne particulates on two separate membrane filters with a cut point of 2.4 μm aerodynamic diameter. The collected filters were then sent to LBL for mass determination of the ranges of particles and elemental analyses. The total mass was determined with a beta gauge. Element concentrations were determined using a fully automated x-ray fluorescence analyzer with a newly developed pulsed x-ray source. This analyzer provided considerably improved detection limits compared to one using a continuous x-ray source.

Parameters Measured	Instrument/Method Used
Silicon, Phosphorus, Sulfur, Chlorine, Potassium, Calcium, Titanium, Vanadium, Manganese, Iron, Nickel, Copper, Zinc, Gallium, Arsenic, Selenium, Rubidium, Strontium, Silver, Cadmium, Tin, Antimony, Barium, Lead, Bromone, Aluminum, Chromium, Mercury	LBL Automatic Dichotomous Air Sampler (ADAS) designed to sample ambient aerosols at a rate of 3m^3/hr. and divide the incoming particles into two aerodynamic size fractions; greater than 2.0 microns and less than 2.0 microns for unit density spheres. The particles were deposited separately on two 37 mm diameter cellulose membrane type filters for subsequent total mass measurements via beta-gauge and elemental analysis via x-ray fluorescence analysis. The effective area of the deposits on the filters is approximately 7 cm^2. The inlet adapter is designed to sample isokinetically from a vertically downward flow of 217 cm/sec. Automatic control functions in the sampler unit allow unattended operation for up to 36 sample exposures for preset time intervals from 1 to 100 hours.

Calibration and Quality Control Procedures

The procedures used for sample collection are described in Section 7.3.4.1.

The beta gauge was re-calibrated after each set of two trays of samples, approximately once an hour, using a film of known weight.

The x-ray equipment was calibrated using either an evaporated film of known weight, by interpolation between two adjoining elements, or against a known compound deposited as an aerosol on a filter. An example of the last procedure was the calibration for sulfur, using an aerosol containing copper sulfate. The sulfur calibration was based on the known copper values.

Location and Type of Data Available

Available data have been deposited in the RAPS Data Bank. Additional information may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Goulding, F. S., J. M. Jaklevic, and B. W. Loo. Development of Air Particulate Monitoring Systems. Lawrence Berkeley Laboratory, Berkeley, California. EPA-IAG-D6-0377. January 1978.

Loo, B. W., W. R. French, R. C. Gatti, F. S. Goulding, J. M. Jaklevic, J. Llacer, and A. C. Thompson. Large-Scale Measurement of Airborne Particulate Sulfur. Atmospheric Environment, 12:759-771, 1978.

Goulding, F. S., J. M. Jaklevic, and B. W. Loo. Aerosol Analysis for the Regional Air Pollution Study. Interim Report. Lawrence Berkely Laboratory, Berkeley, California. IAG-D6-0670. July 1978. EPA-600/4-78-034.

7.3.5 AEROSOL MONITORING SITE SURVEYS

7.3.5.1 FUGITIVE DUST SURVEY AND INVENTORY

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Funding EPA Contract No. 68-02-2093, Task Order No. 124

Period of Performance May - June 1977

Summary

Ten RAMS sites and two special study sites where hi-vol samplers had been used to collect particulate data as part of RAPS were surveyed to assess the impact of ground-level fugitive dust sources within a one mile radius of each site. The RAMS sites surveyed were 103, 105, 106, 108, 112, 115, 118, 120, 122, and 124. In addition, the special hi-vol study sites on the Municipal Courts Building at 14th and Market and at the City Air Monitoring Station No. 2 at South Broadway and Hurck were surveyed.

Each site was visited and the surrounding area was surveyed to determine the extent of any ground level fugitive dust sources. The area within a 1.6 km radius of each hi-vol location was subdivided into annular ring segments each of which was thoroughly examined to detect all ground level fugitive dust sources, and an inventory of all such sources was compiled. Source types are shown in Table 13. Both black and white and color photographs of the area within a 0.4 km radius of each site were taken from a helicopter. A sketch was also made of the area within a 0.4 km radius.

TABLE 13. FUGITIVE DUST SOURCE CATEGORIES IN THE ST. LOUIS STUDY AREA

- Cleared Areas
- Active Construction
  - Building construction
  - Highway construction
- Playgrounds and athletic fields
- Reentrained dust from paved streets
  - Normal streets
  - Commercial (dirty) streets
- Unpaved roads
- Railroad right-of-ways and yards
- Agriculture
  - Tilling operations
  - Wind erosion

Once particulate sources were identified, their emissions were calculatd using emission factors. Fugitive dust factors frequently required special adjustment for applicability to the St. Louis area, whereas industrial particulate emission factors were in general the standard AP-42 factors. Significant point sources of particulates were identified by their RAPS I.D. codes. Site surveys, emission factors, and emission calculations are thoroughly documented in the task order final report which was submitted along with a set of color photographs of the stations to the EPA Task Coordinator.

Copies of the final report and additional information may be obtained from the EPA Task Coordinator.

Publication

Griscom, R. W., F. E. Littman, and E. O. Nelson. Fugitive Dust Survey and Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 124 Final Report, EPA Contract 68-02-2093. October 1977.

7.3.5.2 DOCUMENTATION OF SOURCES AND LAND USE

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Task Coordinator

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Office of Air Quality Planning
& Standards
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Funding EPA Contract No. 68-02-2093, Task Order No. 131

Period of Performance November 1977 - January 1978

Summary

Under Task Order No. 124 (Section 7.3.5.1), ten RAMS sites and two special study sites where high volume samplers had been operated were surveyed to assess the impact of ground-level fugitive dust sources within a one-mile radius of each site. The documentation of sources and land use under Task Order No. 131 was intended to complement the fugitive dust survey by assembling additional pertinent information on the area in each compass quadrant around the same twelve stations and by extending the radius of consideration from one to three miles. Additionally, a list of all point sources and emissions within a five-mile radius of these twelve stations and 35 agency operated aerosol monitoring sites located in the RAPS study area was compiled.

The subjects of the land use documentation were RAMS Sites 103, 105, 106, 108, 112, 115, 118, 120, 122, and 124; the Municipal Courts Building at 14th and Market Streets; and the City Air Monitoring Station No. 2 at South Broadway and Hurck. The land around each site was carefully studied from aerial photographs and site visitations. Based on these surveys, the percentage of land use per quadrant between one and three miles radial distance from each site was estimated for each of the following categories: agricultural, commercial, industrial, residential, and undeveloped (land versus water).

In addition to these twelve sites, 35 additional stations operated by local agencies in the RAMS study area were designated as aerosol sampling sites. A computer listing was prepared identifying all particulate point sources within a five-mile radius of each of the 47 sampling sites. The tabulation included the type of industry, location and distance from site, particulate matter emission level, and stack height.

The land use and particulate source information are documented in the task order final report along with aerial photographs of the twelve main sites. Copies of the final report and additional information may be obtained from the EPA Task Coordinator.

Publication

Nelson, E. O., and F. E. Littman. Documentation of Sources and Land Use Around RAPS Aerosol Sampling Sites. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 131 Final Report, EPA Contract 68-02-2093. June 1978.

7.4 POLLUTANT REMOVAL PROCESSES

7.4.1 SULFUR DIOXIDE FLUX MEASUREMENTS

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Funding

EPA Grant No. R-803896 to Washington University
Washington U. Subcontract No. WU-76-2A to EQR

Period of Performance August 1974

Technical Approach

At least two types of information are required for a more complete assessment of the importance of SO_2 surface removal processes. In an attempt to understand the basic phenomenology, information is needed to define under which conditions the surface absorption efficiency is the rate-controlling factor, and under which conditions the SO_2 supply to the surface by turbulent exchange process is a vital mechanism. Secondly, field data are needed to successfully parameterize the complex surface removal processes in terms of simpler quantities, such as bulk deposition velocities and surface fluxes. This parameterization is essential for support of air quality simulation and aerosol dynamics modeling efforts.

In view of these two basic requirements, the specific objectives of this study were: (1) to design and test a mobile system for field measurement of

SO_2 surface flux and deposition velocity; (2) to formulate software for calculation of boundary layer meteorological parameters needed for the SO_2 flux estimation, using meteorological data from the field system; (3) to obtain characteristic SO_2 surface fluxes and deposition velocities relevant to selected surface-based point source plumes in the St. Louis area under summertime vegetation conditions.

Periods of Data Collection

Data were collected at seven selected sites in the St. Louis Metropolitan Area during the period of August 3-23, 1974. Additional measurements were conducted during subsequent MISTT experiments, but details are currently unavailable.

Parameters Measured	Instrument/Method Used
Measurement Platform	Seven-meter, 3-section radio antenna tower fitted with a leveling base.
Wind Speed and Direction	Dual-gimbaled vaned anemometer mounted at 1, 3, and 7-m levels on the tower.
Temperature	Radiation-shielded power-aspirated thermistor mounted at 1, 3, and 7-m levels on the tower.
Sulfur Dioxide	Theta Sensor monitor mounted on an elevator; could be cycled from surface to 6-m level.
Ozone	Dasibi UV absorption monitor mounted on an elevator; could be cycled from surface to 6-m level.

Data acquisition, AD conversion, and recording of meteorological parameters and ozone concentration was accomplished with a Metro-Data 620L data logger with 20 channels sampled at a rate of 2.5/sec. So_2 concentrations from the Theta sensor were recorded on strip charts.

Location and Type of Data Available

Analyses of selected data are contained in the report referenced below. Additional data and information may be obtained from the Principal Investigator.

Publications

Dannevik, W. P., S. Frisella, and J. Fishman. RAPS 1974 SO_2 Surface Flux Measurement Program. Environmental Quality Research, Inc., Clayton, Missouri. Subcontractor Report for EPA Grant R-803896. December 1974.

Dannevik, W. P., S. Frisella, L. Granat, and R. B. Husar. SO_2 Deposition Measurements in the St. Louis Region. Proceedings of Third Symposium on Atmospheric Turbulence, Diffusion, and Air Quality. Raleigh, North Carolina. October 1976.

7.4.2 PRECIPITATION SCAVENGING OF INORGANIC POLLUTANTS

Principal Investigator	Project Officer
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Funding

EPA Interagency Agreement No. IAG-D4-0323
Program Element No. 1AA009

Period of Performance July 1972 - June 1974

Technical Approach

The objective of this study was to formulate reliable precipitation scavenging submodels in accordance with the overall modelling objectives of the Regional Air Pollution Study. Precipitation scavenging is an important component of atmospheric response as pollutants are removed from the atmosphere and delivered to the earth's surface. The approach taken to develop this submodel was to formulate a macroscopic material balance over the metropolitan complex. However, it was obvious that no reasonable field experiment could be designed to accurately complete the balance equation. Consequently, the emphasis was placed on the direct measurement of scavenging fluxes through the use of precipitation sampling array that in conjunction with limited support operations and other sources of data would allow the approximation of the necessary material balance information. Other sources of information included data from the St. Louis Air Pollution Control District

Network, the Illinois EPA network, the CAMP station, the National Weather Service and the participants in the METROMEX project.

This study consisted of two field programs which were conducted during the summers of 1972 and 1973. The major measurement effort, the precipitation chemistry arrays, were located both upwind and downwind of the St. Louis Metropolitan Complex as shown in Figures 11 and 12. Radiosondes released by Battelle were launched from Lambert - St. Louis International Airport.

Periods of Data Collection

Data were collected on potential convective storm days during the following periods:

August 8-31, 1972
July 9-27, 1973

Parameters Measured	Instrument/Method Used
Precipitation Samples	Homemade sampler consisting of a 500 ml plastic bottle attached to a 20 cm diameter funnel enclosed in a styrofoam container with 1 kg of dry ice. In the 1973 study a homemade sequential rain sampler with a 1 m^2 plastic funnel mounted on an automobile was used.
pH	Measured by a standard glass electrode.
Sulfur Dioxide (dissolved)	Technicon autoanalyzer using a modified West & Gaeke Method.
Sulfate	Technicon autoanalyzer using a methylthymol blue method.
Nitrate	Technicon autoanalyzer using a phenoldisulfonic acid method and chromotropic acid method.
Ammonium	Technicon autoanalyzer using a phenoldisulfonic acid method.

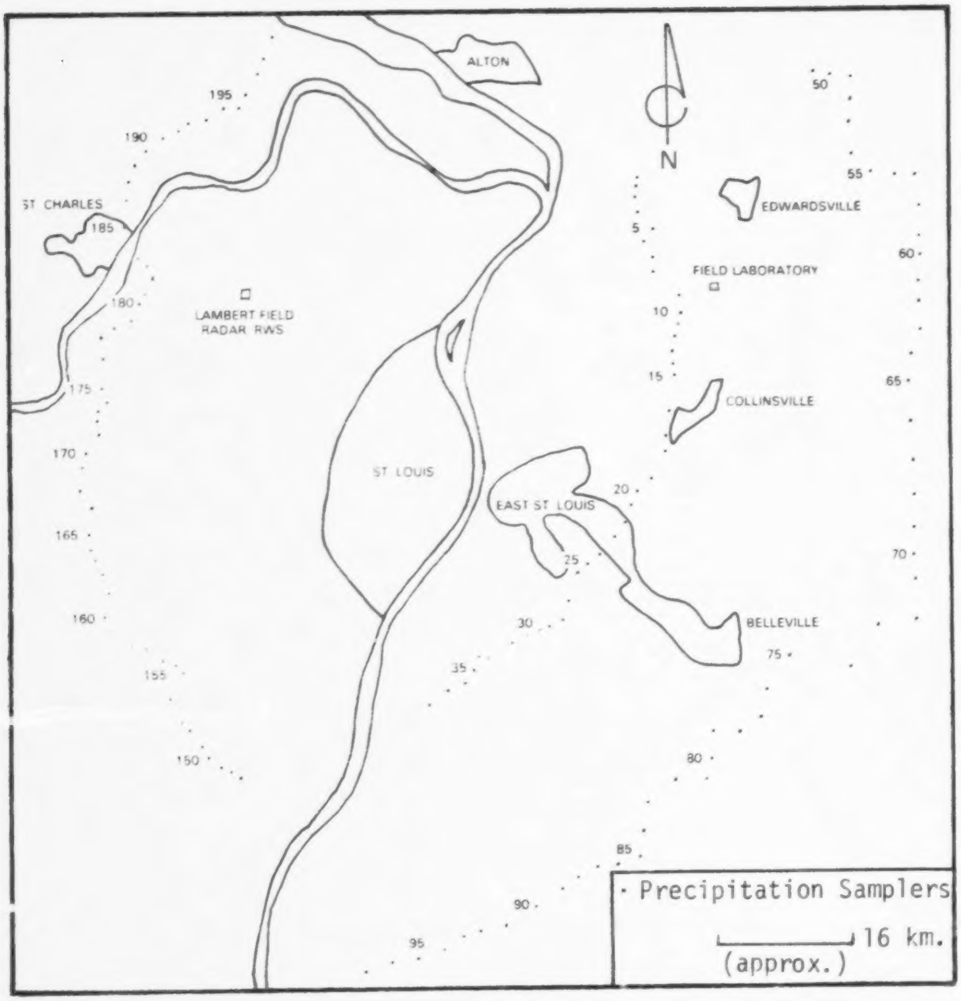

FIGURE 11. PRECIPITATION SAMPLING ARRAY: AUGUST 1972.

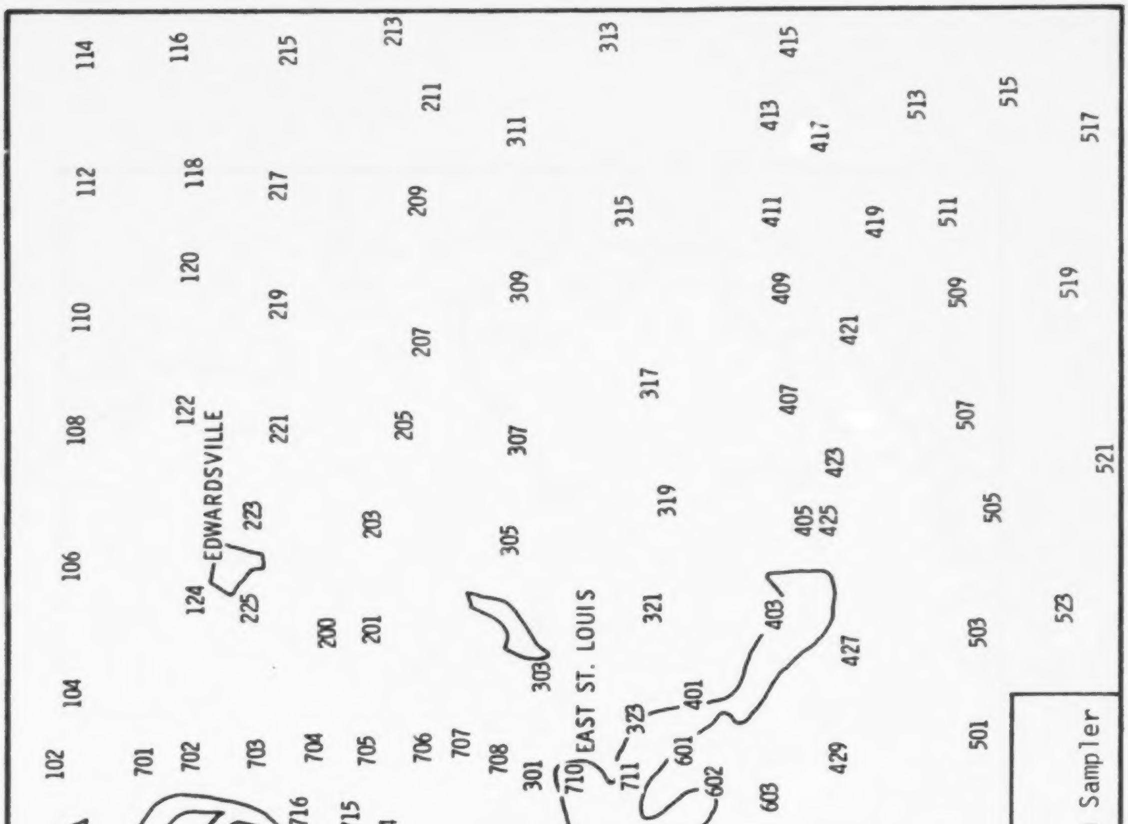

FIGURE 12. PRECIPITATION SAMPLING ARRAY: JULY 1973

Parameters Measured	Instrument/Method Used (continued)
Nitrite	Technicon autoanalyzer using the Saltzman method.
Temperature, Relative Humidity, Wind Direction and Wind Speed Aloft	1680 MHz radiosonde equipped with a standard thermistor, hygristor and baroswitch. The unit, carried aloft with a 300-gram balloon, was tracked with a Weather Measure rawinsonde receiving station.

Reduction methodologies are the same as those used by the National Weather Service and found in Federal Meteorological Handbook No. 3 - Radiosonde Observations. A pressure of 400 mb (approximately 7 km) or less had to be obtained to constitute a valid flight. Significant levels were selected whenever the temperature deviated ± 1°C from the established lapse rate and whenever the relative humidity deviated 10% or more from the established trend.

Calibration and Quality Control Procedures

Rain samples were kept frozen until just before chemical analysis which was completed at the Battelle mobile lab, generally within a few days after collection. Standard buffer solutions were used to calibrate the pH meter while standard solutions were subjected to the same analytical procedures to check the Technicon Autoanalyzer. The samples which were returned to Richland, Washington were subjected to repeat nitrogen pollutant analyses, both as a check on initial procedures and as a limited evaluation of post-collection changes. In addition, an independent method of nitrate analysis was performed as a check on the nitrate procedure. Good agreement was observed between the two methods of nitrate analysis, but there was a scatter of about ± 15% on some individual analyses. The second analysis for ammonium ion, which took place after several stages of thawing and freezing for prior analyses, showed systematically higher readings.

The radiosondes and associated receiving equipment were calibrated according to National Weather Service and manufacturer's recommendations and procedures.

Location and Type of Data Available

The data are contained in the final report referenced below.

Publication

Dana, M. T., J. M. Hales, C. E. Hane, and J. M. Thorp. Precipitation Scavenging of Inorganic Pollutants from Metropolitan Sources. Battelle, Pacific Northwest Laboratories, Richland, Washington. EPA Interagency Agreement IAG-D4-0323. June 1974. EPA-650/3-74-005.

8.0 POLLUTANT MEASUREMENT PROGRAM

Introduction

The RAPS, based upon the best available monitoring instrumentation at the time of its design, provided an excellent opportunity to test new instruments and techniques for monitoring air quality. Comparison with RAMS measurements and with other appropriate standards enabled evaluation of both gaseous pollutant and aerosol monitors.

A second component of the pollutant measurement program was a variability study to quantitatively assess the spatial representativeness of the RAMS air quality and meteorological observations over a one-kilometer square grid employed by most mathematical simulation models.

Data quality investigations including comparison audits, cross calibrations, and standards verification comprised the third category of the pollutant measurement program.

8.1 POLLUTANT VARIABILITY STUDIES

8.1.1 EPA/RAPS WINNEBAGO VARIABILITY STUDY

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-1081, Task Order No. 44

Period of Performance August - September 1974

Technical Approach

This study was performed in conjunction with experiments conducted during the Summer 1974 Expeditionary Research Program to study pollutant transport and dispersion.

The EPA Mobile Laboratory Van (Winnebago) was used to support studies of sub-grid pollutant variability, pollutant transport and reaction in plumes, and to perform detailed mapping of pollutants and characterization of source emissions. The van was also used to support studies of roadway models. The mobile laboratory van was capable of operating while in motion or stationary, and performing measurements of oxides of nitrogen, ozone, total sulfur, light scattering, and air sample bag collections for subsequent analysis in the RAPS gas chromatography laboratory.

Rockwell International, Air Monitoring Center provided operational support services to the EPA during August and September 1974 in assisting experiments utilizing the mobile laboratory van.

Periods of Data Collection

Field operations began formally August 9, 1974 and were conducted through August 30, 1974. During this period a total of seventeen data collection sorties were run on eleven different days. A tabulation of these sorties and data collection on each is presented in Table 14. The table also identifies the data that have been tabulated from the strip chart recordings.

While conducting the field operations and sortie missions, two laboratory logbooks were maintained, which documented all events pertinent to each sortie.

Parameters Measured	Instrument/Method Used
Oxides of Nitrogen (NO, NO_X)	Bendix Model 8101-B NO_X Analyzer using the chemiluminescent method of operation. Lower detectable limit of 5 ppb.
Ozone (O_3)	Bendix Ozone Monitor using the chemiluminescent method of operation. This sensor determined ozone concentration by mixing a fixed air flow with a fixed ethylene flow, and measuring any light output as a result of this with a photomultiplier tube. Lower detectable limit of 0.001 ppm.
Sulfur Dioxide (SO_2)	Meloy Laboratories, Inc. Model SA-185 SO_2 analyzer based on the chemiluminescence of sulfur compounds produced in a hydrogen rich flame. This sensor employed a narrow band pass filter which filtered the light before it was passed to a photomultiplier tube. This flame photometric detector sensor provided continuous measurement of gaseous sulfur species. Lower detectable limit of

TABLE 14. EPA/RAPS WINNEBAGO VARIABILITY STUDY EXPERIMENTAL PERIODS

DATE	SORTIE TITLE	SITE	TIME CDT		STRIP CHART DATA							ROAD MAPS		BAG	TABULATED DATA						GRID MAPS	DATA TAPE	
			START	STOP	NO	NO_x	SO_2	O_3	BS	BS & SO_2	[illegible]	BURTON	NC	SAMP	X Coor	Y Coor	NO_x	SO_2	O_3	BS			
8-9-74	1st Sortie, Test Run	106 105	16:08	18:24			●		●		●	●	1	●									
8-12-74	Plume Surface Study (Ozone Mapping)	Woodriver Ill.	15:30	15:45			●	●	●		●	●	1	●									
8-14-74	Pollutant Variability	106	10:30	15:00		●	●	●	●	●	●	●	2	●	●	●	●	●	●	●	●		
		105	15:00	18:00		●	●	●	●	●	●	●	1		●	●	●	●	●	●	●		
8-15-74	Plume Surface Study Woodriver - Mascoutah, Ill	Metro St. Louis	11:00	17:32	●	●	●	●	●	●	●		1	●				●	●		●	●	
8-18-74	Plume Surface Study Portage Des Sioux	Woodriver Ill.	08:40			●	●	●	●	●	●	●			●	●		●				●	
8-19-74	Pollutant Variability	103	08:25			●	●	●	●	●	●	●	1									●	
8-20-74	Pollutant Variability	105	05:40	06:50	●	●	●	●	●	●	●				●	●	●	●	●	●			GRID MAPS IN NOTEBOOK
		105	09:45	12:50	●	●	●	●	●	●	●				●	●	●	●	●	●			
		103	06:55	8:50	●	●	●	●	●	●	●	●	1		●	●	●	●	●	●		●	GRID MAPS IN NOTEBOOK
		103	---	---	●	●	●	●	●	●	●	●	1		●	●	●	●	●	●			
8-21-74	Plume Surface Study	NW St. Louis	08:34	16:39		●	●	●	●	●	●	●	2		●	●		●			●	●	
8-26-74	Plume Surface Study	Woodriver & Portage De Sioux	13:00	17:15		●	●	●	●	●	●	●	2						2			●	
8-28-74	Pollutant Variability	108	09:18	10:50		●	●	●	●	●	●	●	1		●	●	● NO	●	●	●	●	●	GRID MAPS IN NOTEBOOK
		103	11:55	14:05		●	●	●	●	●	●	●	1		●	●	●	●	●	●			
	Plume Surface Study Granite City Steel		14:20	15:22		●	●	●	●	●	●	●	1		●			●			●		
8-30-74	Pollutant Variability	108	11:10	13:08		●	●	●	●	●	●	●									●		
		Forest Park	14:27	15:04		●	●	●	●	●	●	●	1										
																							MOBILE LABORATORY SORTIES SUMMER 1974

Parameters Measured	Instrument/Method Used (continued)
	0.005 ppm. Effective measurement height of 4 meters. Range of 0.0 to 0.2 ppm or 0.0 to 1.0 ppm, auto ranged.
Light Scattering Coefficient (b_{scat})	Meteorology Research, Inc. Model 1561 Integrating Nephelometer. An air sample was drawn into the interior of the instrument and illuminated by light from an opal glass diffuser, which was illuminated by a continuously operating quartz-halogen incandescent lamp. A reference phototube maintained a constant light intensity. Both phototubes had optical filters to correct the spectral response of the instrument to that of the human eye. The photomultiplier tube viewed a small solid angle parallel to the diffuser surface. It measured the scattering portion of the extinction coefficient of an air sample. The scatter coefficient obtained was the sum of the aerosol scatter and Rayleigh scatter from atmospheric gases. Effective measurement height of 5 meters. Range of 0.1 to 10 x 10^{-4} reciprocal meters. Accuracy of ± 10% of scale. Flow rate of 0.0024 cubic meters per second.

Calibration and Quality Control Procedures

Calibration checks of all instruments were accomplished on August 8, 1974. A check of the Bendix NO, NO_2, NO_X analyzer was performed using a mixture of NO in nitrogen (Scott, Syl. A-1883). Comparisons of NO were performed with the Bendix analyzer of the Mobile Laboratory, titration with O_3 at Scott Air

Force Base, and the Bendix analyzer at a CAMP station.

A calibration check of the Bendix ozone analyzer was made using eight comparison measurements with a Dasibi model 1003-AH monitor. The source of O_3 was from a Monitor Laboratories, Inc. 8500 calibrator.

The Meloy sulfur analyzer was calibrated using the output of an NBS permeation diluted with zero air from the Bendix Dynamic calibration system. The Meloy instrument indicated a tendency to drift, increasing about 0.01 ppm per fifteen minutes.

Location and Type of Data Available

Data collected during field operations were transmitted to the EPA Task Coordinator and consisted of:

A. 62 strip chart recordings
B. 9 Metro-Data Logger magnetic tapes
C. Laboratory record
D. Logbook, data tabulations

All data are recorded on magnetic tape as part of the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Jones, A. C. Mobile Van Operation (Winnebago). Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 44 Final Report, EPA Contract 68-02-1081. June 1977.

8.1.2 SUBGRID POLLUTANT VARIABILITY

8.1.2.1 MOBILE POINT MONITORS

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Funding EPA Contract No. 68-02-1081, Task Order No. 43

Period of Performance July - September 1974

Summary

In compliance with Task Order No. 43 five portable point monitors were fabricated. Each monitor consisted of a "Kelty" backpack which was modified to house an air pump and a 28 liter Teflon sample bag holder. The air pump was operated by a 6 volt DC motor which was powered by a 6 volt, 10 amp hour battery. A hose and intake manifold for drawing in the sample were attached. This sampling system was capable of 30 minutes of continuous sampling at a flow rate of approximately one liter per minute, meeting performance requirements set by the EPA. The samples were subsequently analyzed for carbon monoxide and ozone.

Appropriate personnel were hired and trained to operate the monitors. The monitors were delivered to the EPA Task Coordinator upon completion for use in the Long Path Monitoring and Pollutant Variability studies (Sections 8.2.1 and 8.1.2.2).

Publication

Jones, A. C. Operational Support for Long Path Monitoring and Pollutant Variability Study. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 43 Final Report, EPA Contract 68-02-1081. October 1974.

8.1.2.2 CO AND O_3 VARIABILITY

Principal Investigator

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Funding EPA Grant No. 803399

Period of Performance July - September 1974

Technical Approach

The purpose of this experiment was to investigate the pollutant variability in an area represented by a stationary point monitoring site. The experiment consisted of placing mobile monitors at various points within a one kilometer radius of a stationary (RAMS) station and taking simultaneous measurements for subsequent comparisons.

RAMS sites 105 and 108 were selected as test sites as they represented urban and rural locations respectively. The two pollutants chosen for monitoring were ozone and carbon monoxide because the pollutant variabilities for these two gases was expected to be different as carbon monoxide is a primary pollutant and ozone is a secondary pollutant.

At each site, four locations were selected and simultaneous readings at the station and at two of the locations were taken for 20 minutes. The mobile equipment was moved to the other locations and the sampling sequence repeated. Ozone was monitored with two portable monitors and carbon monoxide was measured by collecting bag samples at the locations which were later analyzed with a gas filter correlation monitor (Section 8.2.2).

In addition to measuring the pollutant variability around the RAMS stations, the mobile monitors were used to gather data along the laser paths of two long path monitors which were being field tested (Section 8.2.1).

Period of Data Collection

Samples collected as 20 minute averages were obtained over selected periods from July 1 through September 15, 1974.

Parameters Measured	Instrument/Method Used
Ozone	Analytical Instrument Development, Inc. Model 801 portable ozone monitor.
Carbon Monoxide	Bag samples were collected in 28 liter Teflon bags and analyzed with Philco-Ford gas filter correlation spectrometer (Section 8.2.2).

Calibration and Quality Control Procedures

The ozone monitors were calibrated twice daily using an ozone generator. The ozone monitors were also normalized against the RAMS station before and after each sampling period.

Location and Type of Data Available

For information on data availability or for additional information contact the EPA Project Officer.

Publication

McClenny, W. A., and L. W. Chaney. Pollutant Variability in the Regional Air Pollution Study. Journal of the Air Pollution Control Association, 28(7):693-696, 1978.

8.2 INSTRUMENT EVALUATION STUDIES

8.2.1 LONG PATH MONITORING

8.2.1.1 EPA (MIT LINCOLN LABORATORY) MOBILE LASER

Principal Investigators

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Funding

NSF Grant No. ENV 73-07760 A04
EPA Interagency Agreement IAG-D4-0465
NSF Contract No. NSF/RANN/IT/GI-37603

Period of Performance March 1975 - March 1976

Technical Approach

As part of the Environmental Protection Agency's interest in the development and evaluation of new instruments for the monitoring of atmospheric pollutants, long-path laser techniques were included in the Regional Air

Pollution Study. The purpose of this contract was to provide for the field operation and validation of an ambient air monitoring system which incorporated a low-power, tunable, semiconductor diode laser. This system, developed by Lincoln Laboratory, enabled integrated path measurements of pollutant gases using the operating principle of resonance absorption in the infrared.

The monitoring system was placed in a mobile van and used to measure carbon monoxide at several sites (St. Louis University, RAMS Sites 105 and 108) during selected periods in 1974 and 1975.

Periods of Data Collection

Data were collected at various intervals during the following periods:

August 16 - September 3, 1974	St. Louis University
September 10 - 18, 1974	RAMS Site 108
September 21 - October 3, 1974	RAMS Site 105

Data were collected continuously during the following periods:

July 7 - August 3, 1975	RAMS Site 108
August 7 - September 10, 1975	RAMS Site 105

Parameters Measured	Instrument/Method Used
Carbon Monoxide Burden	In 1974 a semiconductor diode laser manufactured at Lincoln Laboratory was used. In 1975 lasers manufactured by Laser Analytics was used.
Carbon Monoxide (for comparison with long path measurements)	Samples were taken with portable back pack samplers (Section 8.1.2.1) and analyzed at the RAPS gas chromatography laboratory (Section 7.2.1). A gas filter correlation monitor was also used (Section 8.2.2).

Information on the RAMS data and equipment used for comparison may be found in Section 3.0.

Calibration and Quality Control Procedures

Calibrations of the long-path measurement equipment were performed in 1974 and 1975 at frequent intervals with calibration cells containing known concentrations of carbon monoxide in nitrogen mixtures at atmospheric pressure. Several mixtures were used to establish the system response curve. This procedure was used to supply a known additional CO burden during long path measurements.

In the 1974 study, the laser data was compared to three other sources of data. The following sources of data were used:

1) Bag (28 liter) samples were collected along the laser path and analyzed later by the RAPS gas chromatography laboratory (Section 7.2.1).

2) RAMS data from the station adjacent to the van.

3) Real time portable point monitors (Section 8.1.2.1).

In the 1975 study, comparisons of the laser data were made to RAMS station point readings and/or a gas filter correlation instrument (Section 8.2.2).

Location and Type of Data Available

All of the data from the 1974 and 1975 studies are in the form of 24-hour plots in the progress report referenced below.

Publications

Ku, R. T., E. D. Hinkley, J. O. Sample, L. W. Chaney, and W. A. McClenny. Long-Path Laser Monitoring of Atmospheric Pollutant Gases. In: Proceedings of the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, 1975. Paper 75-56.5.

Chaney, L. W., W. A. McClenny, and Robert T. Ku. Long Path Monitoring of CO in the St. Louis Area. In: Proceedings of the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, 1975. Paper 75-56.6.

Ku, R. T., and E. D. Hinkley. Long-Path Monitoring of Atmospheric Carbon Monoxide. Lincoln Laboratory, Lexington, Massachusetts. Progress Report NSF Contract NSF/RANN/IT/GI-37603. April 1976.

8.2.1.2 GE CARBON DIOXIDE LASER VAN

Principal Investigators

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Funding EPA Contract No. 68-02-1290

Period of Performance May 1974 - May 1975

Technical Approach

In the development of new methods and equipment for the in-situ monitoring of atmospheric pollutant gases over extended paths, this contract specified modifications of the ILAMS (Infrared Laser Atmospheric Monitoring System) and a period of operational tests in the St. Louis Area in conjunction with the RAPS program (RAMS Site 103). The modifications to the ILAMS included the change to a six wavelength configuration to monitor three target gases of ozone, ammonia and ethylene as well as incorporation of a beam steering capability.

The field experience in St. Louis produced data which correlated reasonably with point monitor instruments, however, the investigators noted that there was room for improvement in the performance of the system because:

1) Optical effects on the six wavelength beam pattern were a principal source of error.
2) Changes in signal processing could significantly reduce short term excursions in ozone concentration measurements.

3) Spectral effects not factored into the wavelength selection process were a source of error occurring under certain conditions.

4) Zeroing of the system, independent of other gas monitoring instruments was an important feature which must be incorporated to make the system useful for monitoring.

Period of Data Collection

Data were recorded continuously from approximately 0900 to 1900 CST daily during the period of August 15, 1974 through October 12, 1974.

Parameters Measured	Instrument/Method Used
Total Burden of Ozone, Ethylene and Ammonia	Breadboard configuration of a carbon dioxide laser, reflectors, interfaces, PDP 11/05 processor and an ASR-33 teletype.
Ozone	Analytical Development, Inc. (AID) Model No. 560 chemiluminescent analyzer.

Calibration and Quality Control Procedures

Comparisons of the laser measurements to the point monitor (Section 8.1.2.1) were made at frequent intervals during the study period. The point monitor usually was positioned just outside the monitoring trailer or was carried along the laser's path.

Location and Type of Data Available

Data are available in strip chart form from the Project Officer. Portions of the data are included in the report referenced.

Publication

Gillmeister, R. J., and L. R. Snowman, Carbon Dioxide Laser System to Measure Gaseous Pollutants. General Electric, Pittsfield, Massachusetts. EPA Contract 68-02-1290. January 1977. EPA-600/7-77-009.

8.2.1.3 ENVIRONMENTAL MEASUREMENTS MOBILE VAN

Principal Investigator

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Funding EPA Contract No. 68-02-1851

Period of Performance July 1974 - February 1975

Summary

Environmental Measurements, Inc. (EMI), in response to a request by the EPS's Field Methods Development Section, carried out a demonstration of remote sensing and moving laboratory methodologies. One purpose was to investigate the performance of the Barringer Research COSPEC III Remote Sensing Correlation Spectrometer as a longline ambient monitor. The spectrometer is described in Section 7.1.1.3.

The longline study was designed to provide spatially integrated ambient air monitoring for SO_2 over a path of 845 meters, extending to the northeast of RAMS Site 103. Efforts were made to coordinate EMI's measurements with the longline measurements being conducted by General Electric (Section 8.2.1.2) so that simultaneous SO_2 and NH_3 data could be compared. Due to equipment problems, however, few NH_3 measurements were obtained concurrent with EMI's field measurements. The ground-level variability study was to define the temporal and spatial variation within approximately one km of RAMS Sites 102, 103 and 108, and to provide point monitor data along the longline path at RAMS Site 103.

The EMI van procured measurements from September 23 through October 7, 1974, including 8 data-days of longline measurements, 3 of which were continuous for more than 30 hours. Six data-days of ground-level variability measurements were also completed.

Location and Type of Data Available

Longline and variability data in graphical form and copies of chart records may be found in the references cited under Publications. Questions may also be directed to the Principal Investigator.

Publication

Vaughan, W. M., and R. B. Sterling. Limited SO_2 and NO_X Measurements in St. Louis, 1974: Volume II - Longline Ambient SO_2 Monitor and Variability of SO_2 and NO_X. Environmental Measurements, Inc., San Francisco, California. EPA Contract 68-02-1851. January 1975.

8.2.2 GAS FILTER CORRELATION MONITOR FOR AMBIENT CARBON MONOXIDE

Principal Investigator	Project Officer
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Funding EPA Grant No. 803399

Period of Performance June 1975 - October 1976

Technical Approach

The gas filter correlation (GFC) monitor is a convenient, specific, sensitive, fast-response carbon monoxide monitor developed for use in air quality monitoring and atmospheric modeling studies. It is useful over the full range of probable carbon monoxide concentration from 50 ppb to the parts-per-million levels. The gas filter correlation monitor is an instrument that measures changes in transmission of radiation due to absorption by gaseous species. The uniqueness of the monitor is in the manner in which the target gas absorption is separated from the absorption due to other species. Specifically, this is accomplished in a signal processing procedure that utilizes an optical filter cell containing a high concentration of the target gas.

The GFC monitor underwent several field and performance tests during the Regional Air Pollution Study. Consequently the data gathered by this instrument is an additional source of carbon monoxide data collected in the St. Louis Area. Essentially three types of field tests were conducted:

1. roadside measurements

2. long-term comparisons with a gas chromatograph flame ionization detector for CO at selected RAMS sites

3. helicopter measurements.

Periods of Data Collection

July - August 1975	RAMS Site 105
September 11, 1975	RAMS Site 106
September 15, 1975	RAMS Site 122
August 12, 1976	RAPS Helicopter No. 1
August 20, 1976	St. Louis University

Parameter Measured	Instrument/Method Used
Carbon Monoxide Concentration	Gas Filter Correlation Spectrometer built by Philco-Ford for the EPA.

Information on the gas chromatograph used at the RAMS sites for comparison may be found in Section 3.0.

Calibration and Quality Control Procedures

The instrument zero was determined by flushing the sample chamber with ultra pure zero air as sold by Scott-Marrin, Inc., prepurified argon, high-purified-grade helium and zero grade air as sold by Linde, Inc. The Linde zero air was further purified by passage through a Hopcalite scrubber. Multipoint calibrations were performed with an NBS cylinder of carbon monoxide and nitrogen at 100 ppm which was diluted dynamically with one of the zero air sources. The H_2O channel was calibrated by establishing reference signals at 0 and 100% relative humidity by bubbling zero air through water.

Location and Type of Data Available

Information on data availablity may be obtained from the EPA Project Officer. A grant report will be available about August 1979.

Publication

Chaney, L. W., and W. A. McClenny. Unique Ambient Carbon Monoxide Monitor Based on Gas Filter Correlation - Performance and Application. Environmental Science and Technology, 11(13):1186-1190, 1977.

8.2.3 AEROSOL MEASUREMENTS

8.2.3.1 CABOT SULFURIC ACID AEROSOL ANALYZER

Principal Investigator

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Funding Environmental Protection Agency

Period of Performance August - September 1975

Technical Approach

A new sulfuric acid monitor, fabricated for the EPA by Cabot Corporation, was field tested for the first time in St. Louis at RAMS Sites 106 and 124. The principle of operation of this monitor involves filter collection of ambient particulate matter followed by separation of the sulfuric acid from the other sulfur particles by low temperature volitilization. The amount of sulfuric acid volitilized was then determined with a Meloy flame photometric sulfur gas analyzer.

Since the monitor is a combination sampler/analyzer, two filters are active at all times. Ambient air flows through one of the filters to collect the particulate matter and simultaneously dry heated (130°C) air flows through the other to volatilize sulfuric acid collected during the previous cycle. Fluoropore filters were used because of their inertness and collection efficiency.

Periods of Data Collection

August 18 - 28, 1975	RAMS Site 106
August 29 - September 7, 1975	RAMS Site 124

Parameter Measured	Instrument/Method Used
Sulfuric Acid Concentration	Cabot sulfuric acid monitor with an attached Meloy sulfur analyzer. Fluoropore filters were used in the monitor. The detection limit of the monitor was 0.8 μg H_2SO_4/m^3 for a one hour sample collection with a precision of ± 20%.

Calibration and Quality Control Procedures

Standard zero and multipoint calibrations were performed on the Meloy portion of the analyzer.

Location and Type of Data Available

The data were not reported as the analyzer was being field tested for the first time. The field test was primarily concerned with the monitor's mechanical performance and response. Additional information may be obtained from the EPA Principal Investigator.

Publication

Stevens, R. K., P. J. Lamothe, W. E. Wilson, J. L. Durham, and T. G. Drzubay. The General Motors/Environmental Protection Agency Sulfate Dispersion Experiment. EPA-600/3-76-035, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1976.

8.2.3.2 TWO-STAGE MASS MONITOR WITH AEROSOL SIZE SEPARATOR

Principal Investigator	Project Officer
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Funding

Work was partially supported under EPA Grant No. R803115

Period of Performance

January 1974 - September 1975

Technical Approach

The two-stage on-line mass monitor with aerosol size separator (TWOMASS) employs the beta attenuation technique to monitor atmospheric aerosols with high time resolution. TWOMASS independently analyzes the mass concentrations of submicron ($d \leq 3$ μm) and supermicron ($d >$ μm) particle size fractions. Coarse particles are inertially separated by impaction on a glass filter paper with cellulose backing while the fine particle fraction is collected on a high-efficiency glass-fiber filter. Carbon 14 is used as the source of beta particles which are detected by a silicon surface-barrier coupled to fast, low noise nuclear electronics. A programmable calculator controls TWOMASS, calculates the mass concentration of each size fraction, plots, prints and stores data on tape. A field test study of the ambient aerosol mass concentration using TWOMASS with 10-minute sampling intervals and moving the filter tapes every 2 hours was carried out in April and August 1975 at RAMS Sites 112 and 106 respectively.

Periods of Data Collection

Single stage version

February 1974	RAPS Field Study

Two stage version

August 1974	RAPS Field Study
April 1975	RAMS Site 112
AUGUST 1975	RAMS Site 106

Parameters Measured	Instrument/Method Used
Total Particulate Mass and Particulate Sulfur	TWOMASS manufactured by Meteorology Research, Inc. (MRI), Meloy SA-160 flame photometric total sulfur sensor.

Calibration and Quality Control Procedures

TWOMASS was gravimetrically calibrated with several laboratory aerosols; Glycine ($C_2H_5NO_2$), Ammonium Sulfate [$(NH_4)_2 SO_4$], Zinc Chloride ($ZnCl_2$), Sodium Chloride (NaCl), as well as ambient aerosol from the St. Louis area. The results of these measurements yield an exponential relationship between beta attenuation and gravimetric mass both for laboratory aerosols and atmospheric aerosols.

Location and Type of Data Available

For information on data availability contact the EPA Project Officer.

Publications

Macias, E. S., and R. B. Husar. High Resolution On-Line Aerosol Mass Measurement by the Beta Attenuation Technique. Paper presented at Second International Conference on Nuclear Methods in Environmental Research, Columbia, Missouri. July 1974.

Macias, E. S., and R. B. Husar. A Review of Atmospheric Particulate Mass Measurement Via the Beta Attenuation Technique. In: Fine Particles: Aerosol Generation, Measurement, Sampling and Analysis, B.Y.H. Liu, Editor. Academic Press, New York. 1976. pp. 535-564.

Publications (continued)

Macias, E. S., R. B. Husar, and J. D. Husar. Monitoring of Atmospheric Aerosol Mass and Sulfur Concentration. In: Proceedings of the International Conference on Environmental Sensing and Assessment, Las Vegas, Nevada. 1975.

Husar, J. D., R. B. Husar, E. S. Macias, W. E. Wilson, J. L. Durham, W. K. Shepherd, and J. A. Anderson. Particulate Sulfur Analysis: Application to High Time Resolution Aircraft Sampling in Plumes. Atmospheric Environment, 10:591-595, 1976.

Macias, E. S., and R. B. Husar. Atmospheric Particulate Mass Measurement with Beta Attenuation Mass Monitor. Environmental Science & Technology, 10:904-907, 1976.

8.2.3.3 MANUAL DICHOTOMOUS AIR SAMPLERS

Principal Investigators

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Funding Environmental Protection Agency

Period of Performance

August - September 1975

Technical Approach

As an alternative to the high volume sampler, a dichotomous sampler capable of separately collecting the respirable and nonrespirable fractions of atmospheric aerosols was developed. Another advantage of the dichotomous sampler was that it was designed to accommodate membrane filters which are required for X-ray fluorescence analyses (XRF).

A prototype dichotomous sampler utilizing virtual inpaction was evaluated in the field at St. Louis during the summer of 1973. The purpose of the evaluation was to demonstrate that the dichotomous sampler was compatible with the requirements of both gravimetric mass analysis and X-ray fluorescence elemental analysis. In order to accomplish this, eight dichotomous samplers were tested beside high volume samplers for 20 days at RAMS Sites 106 and 124. The filters were gravimetrically analyzed for mass and analyzed for elemental content by XRF. The samples were then sent to other laboratories

(Section 8.2.3.4) for analysis of carbon, nitrate, sulfur, sulfate and chemical compounds of nitrogen and sulfur. Excellent agreement was obtained in a comparison of the mass collected in the high volume and dichotomous samplers. Good agreement was also obtained among sulfur measurements by the various analytical methods.

Period of Data Collection August 18 - September 7, 1975

Parameters Measured	Instrument/Method Used
Total Suspended Particulates, Sulfur and Sulfates	The sampling equipment operated at each site included five manual dichotomous samplers consisting of an aerosol inlet, a virtual impactor particle separator, vacuum pumps, and flow servocontroller. One automated dichotomous sampler (the sample filters are changed automatically) was used at each site as well as one high volume sampler. Gravimetric analysis was accomplished with a Perkin Elmer AD-2 electrobalance with a radioactive source to eliminate electrostatic charges. XRF was accomplished with a spectrometer equipped with a secondary fluorescence-type excitation source and a Si(Li) type energy dispersive detector.

Calibration and Quality Control Procedures

The X-ray spectrometer was calibrated using film standards obtained from Micromatter Co. The flow controllers for each sampling device were also checked. Other quality control checks were built into the experimental design as this was a comparative study; for example, a total of twelve combinations of methods and samplers were intercompared for sulfur during this study.

Location and Type of Data Available

For information concerning data availability contact the EPA Principal Investigators.

Publications

Dzubay, T. G., and R. K. Stevens. The Characterization of Atmospheric Aerosols by Chemical and Physical Methods. Paper presented at the Division of Environmental Chemistry, American Chemical Society, New York, New York. April 1976.

Dzubay, T. G., and R. K. Stevens. Application of the Dichotomous Sampler to the Characterization of Ambient Aerosols. Paper presented at the Division of Environmental Chemistry, American Chemical Society, San Francisco, California. September 1976.

Dzubay, T. G., R. K. Stevens, and C. M. Peterson. Application of the Dichotomous Sampler to the Characterization of Ambient Aerosols. In: X-ray Fluorescence Analyses of Environmental Samples, T. G. Dzubay, Editor. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan, 1977. pp 95-105.

8.2.3.4 COMPARISON OF WET CHEMICAL AND INSTRUMENTAL METHODS FOR SULFATE MEASUREMENT

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Funding EPA Contract No. 68-02-2273

Period of Performance August - September 1975

Technical Approach

The methylthymol blue (MTB), modified Brosset and barium chloranilate sulfate methods were evaluated for precision, accuracy, working range, interference effects and agreement with x-ray fluorescence analysis (XRF) using atmospheric particulate samples. The samples used were collected by the EPA in St. Louis at RAMS Sites 106 and 124 with dichotomous and hi-vol samplers. The samples were collected simultaneously with glass fiber, quartz fiber and Fluoropore filters, permitting the evaluation of artifact sulfate formation and other filter media-specific effects.

The results indicated agreement within 16% for determining atmospheric sulfate concentrations by the three wet chemical procedures with all three types of filter media. X-ray fluorescence results of the fine particle fraction on Fluoropore filters agreed within 10% of the wet chemical procedures on the same samples and on the average equivalent to the results of the methylthymol blue analyses of glass fiber high volume samples. Small differences in results obtained with different filter media were consistent with the effects of analytical interferents rather than artifact sulfate formation.

Period of Data Collection August 18 - September 6, 1975

Parameters Measured	Instrument/Method Used
Sulfate	Four methods were used to analyze the filters for sulfate. The first method was an automated methylthymol blue (MTB) method which employed the use of a Technicon Autoanalyzer II. The second was a semi-automated modified Brosset method. The third was a manual barium chloranilate (BC) method. The fourth method, XRF, analyzed for sulfur as well as a number of other elements (Section 7.3.4.2). Samples were collected simultaneously with glass fiber, quartz fiber and Fluoropore filters.

Calibration and Quality Control Procedures

Since this was a comparative study, a number of features in the study design facilitated cross checks and comparisons. Two different types of samplers were used to collect samples simultaneously on different filter media. Analyses were done using four different methods. In addition to this cross checking and comparisons, the EPA provided audit strips with known amounts of sulfate that were processed by the various methods before the unknowns.

Location and Type of Data Available

Data and analyses are contained in the final report. Additional information may be obtained from the Project Officers.

Publication

Appel, B. R., E. L. Kothny, E. M. Hoffer, and J. J. Wesolowski. Comparison of Wet Chemical and Instrumental Methods for Measuring Airborne Sulfate. Air and Industrial Hygiene Laboratory, California Department of Health, Berkeley, California. EPA Contract 68-02-2273. November 1977. EPA-600/7-77-128.

8.3 DATA QUALITY INVESTIGATIONS

8.3.1 COMPARISON AUDITS AND CROSS CALIBRATIONS

Task Order No. 58

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Funding EPA Contract No. 68-02-1081, Task Order No. 58

Period of Performance July - August 1975

Summary

A Winnebago van, outfitted for performing comparison audits and cross calibrations, was originally equipped with various monitoring instruments to perform pollutant variability studies under Task Order No. 44 (Section 8.1.1). Under this later task order, multipoint audits were performed during the Summer 1975 Field Expedition on instruments at RAMS sites 105, 113, 120 and 122; on EPA/RAPS helicopters 1 and 3; Battelle and MRI instrumented aircraft; RTI and EMI mobile vans; EPA aerosol trailer; and various individual monitors operated by RAPS principal investigators. The gas sources used in these audits as well as calibration standards are described below. Prior to the audits, the Bendix Calibration System was calibrated against reference standards and NBS standards.

A distinction should be made here between the words "audit" and "calibration". When an instrument is calibrated a gas of known composition is intro-

duced and the instrument is adjusted to respond in accordance with the known gas composition. On the other hand, during an audit, once the gas of known composition is introduced, the instrument reading is simply recorded and no adjustment is made.

Throughout the series of instrument calibrations or audits which were performed, a Bendix Dynamic Calibration System was used. This system employed three precision pressure regulators to maintain a known pressure differential across sets of capillaries for a constant gas flow. These flows were calibrated for various pressure settings using a bubble meter at the beginning of the study. The gas mixture produced by the system was introduced into a glass manifold to produce a demand system operating at atmospheric pressure. Tubing leading to the instrument being calibrated was connected to this manifold. All connectors and connecting tubes were Teflon.

Calibration curves were prepared every time an instrument was calibrated, and the same procedure was followed for each instrument. This procedure consisted of generating various gas concentrations, allowing the instrument to sample them, and taking a reading when the instrument stabilized. This reading along with the known concentration was tabulated and a least squares linear fit was used to determine a slope and intercept.

Parameters	Calibration/Audit Standards
Nitrogenous Oxides	The Calibration van contained a cylinder of approximately 100 ppm of NO which was used as the standard for the NO - NO_X audits. Prior to the first audit, calibration of the 100 ppm cylinder was performed in the RAPS Gas Chromatography Laboratory St. Louis, using a Bendix Model 8101-B NO_X Analyzer that had been calibrated with NBS cylinder # RSG-30-7963 which contained 93.4 ppm NO.
Sulfur Dioxide	For all SO_2 audits two NBS SO_2 permeation tubes were used as standards. When either of the permeation tubes was in use it was placed in the permeation chamber of a Bendix Dynamic Calibration System with the temperature maintained at 25° ± 0.1°C. The output of the Bendix System was cross-checked with the NBS permeation tube in the

Parameters	Calibration/Audit Standards (continued)
	RAMS Station 120 calibration system.
Carbon Monoxide and Methane	An NBS CO cylinder containing 9.82 ppm CO was used in conjunction with the GCL's Beckman 6800 Gas Chromatograph to certify three Scott cylinders, one containing 21.2 ppm CO (#L1722), one containing 2.01 ppm CH_4 and 5.24 ppm CO (#1749) and one containing 2.04 ppm CH_4 and 5.20 ppm CO (#2359). The gas mixtures in these cylinders were diluted with either Matheson zero air or Scott ultrapure air to give a multipoint calibration. A check was made for CO in the zero air and the amount was found to be negligible.
Ozone	The ozone used for the audits was generated on site through the use of a UV tube generator. The ozone generator was calibrated every time ozone was used in an audit by means of an O_3 - NO titration immediately following the calibration of an NO - NO_X analyzer. In this way the instrument calibration was traceable to an NBS NO cylinder. Multipoint audits were obtained by varying the dilution flow of ozone gas.

Location and Type of Data Available

All audit data were included in the final report for Task Order No. 58 referenced below. Original data, in the form of strip charts and tabulations, are currently in the EPA Task Coordinator's possession. Questions should be directed to the Task Coordinator.

Publication

Hribar, John R. EPA Quality Assurance Audits. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 58 Final Report., EPA Contract 68-02-1081. March 1976. EPA-600/4-76-032.

Task Order No. 106

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Funding EPA Contract No. 68-02-2093, Task Order No. 106

Period of Performance February - November 1976

Summary

Task Order No. 106 provided for a continuation of the quality assurance activity initiated under Task Order No. 58. The calibration van was completely refitted with new instrumentation for the task. Several ambient analyzers were installed in the van and a Bendix 8861 protable calibartion system was included for all calibrations. Preparation and calibration of the instrumentation in the van preceded a series of audits of various RAMS sites (101, 102, 104, 107, 111, 112, 114, 115, 120, 125), EPA/RAPS helicopters (1 & 2), four Illinois EPA sites, St. Louis City (1-5) and County (6-9) monitoring network stations, and eight other monitoring systems operated by RAPS principal investigators. This period of operation included the Winter, Summer, and Fall 1976 RAPS Field Expeditions.

In addition to multipoint calibrations or audits, two special projects were conducted. One study (Section 3.3.2) involved analyzing and documenting the effects of new and used Teflon particulate filters placed in the inlet of instruments measuring atmospheric pollutants. The filters had an average pore size of 10 microns and were 47 mm in diameter. Gases measured were NO,

O_3, $NO_2 + O_3$, and $SO_2 + O_3$. Both dry and humidified air were used as diluents.

The second study was made to determine the effect of several variables on the accuracy of SO_2 gas mixtures prepared with a modified Bendix 8861 calibration system. Variables investigated included flow rate through the permeation tube, tube length, position of the permeation tube chamber, and ambient temperature. A Meloy SA185 analyzer was used to monitor the results. Following the study a new chamber was installed in the Bendix 8861 to reduce leakage and facilitate temperature control.

In general, audits were carried out by supplying a calibrated source gas to the instruments being checked. Audits for O_3, NO-NO_X and SO_2 were performed using one zero and four non-zero concentrations. Audits for CO, CH_4 and total hydrocarbons were performed using gases of known concentration from a certified cylinder.

The supply of calibration gas to the instrument being audited or calibrated was regulated by means of the Bendix 8861 Calibration System. Different concentrations were produced by means of this system for multipoint calibrations or audits for all instruments except the Beckman 6800 for which calibration gas was taken directly from cylinders without dilution.

Calibrations were performed on the instruments installed in the calibration van or those which were in the RAPS Gas Chromatography Laboratory and used in the execution of this task order. Audits were performed on RAMS instruments, EPA/RAPS helicopter instruments, etc.

Parameters Measured	Instruments Used
(The following instruments were mounted in the Winnebago van and used for the two special studies.)	
Nitric Oxide, Nitrogen Dioxide	Monitor Labs Model 8440 Oxides of Nitrogen Analyzer
Sulfur Dioxide	Tracor Model 270 HA Atmospheric Sulfur Analyzer
Ozone	Monitor Labs Model 8410 Ozone Analyzer
Total Suspended Particulate	MRI Model 1561 Integrating Nephelometer

Parameters Measured	Instruments Used (continued)
(The following instruments were used for this task order at the RAPS Gas Chromatography Laboratory.)	
Total Sulfur	Meloy Model SA185-2 Total Sulfur Analyzer
Ozone	Bendix Ozone Monitor
Total Hydrocarbons, Methane, and Carbon Monoxide	Beckman Model 6800 Gas Chromatograph
(The following were used for calibrations only and not for pollutant detection. Together they constitute the Bendix 8861 Calibration System.)	
	Bendix Model 8861D Dilution Air System (Modified)
	Bendix Model 8861P Permeation Tube Assembly (Modified)

Calibration and Quality Control Procedures

(NOTE: These are not audit procedures but those used for the van and laboratory instruments.)

Monitor Labs Oxides of Nitrogen Analyzer	Periodic calibration performed using NBS SRM 1684 NO cylinder (100 ppm NO in nitrogen). Also, calibrated for NO_2 generated by the gas phase titration of nitric oxide. Concentrations were regulated with the Bendix 8861D.
Tracor Sulfur Analyzer	Periodic calibration performed using NBS permeation tube 21-71 and NBS SRM 1625, 1626, and 1627 SO_2 cylinders. Concentrations were regulated with the Bendix 8861D.

Calibration and Quality Control Procedures (continued)

Monitor Labs Ozone Analyzer	Calibrated periodically using ozone generated by the Bendix 8861 system. Concentrations were regulated with the Bendix 8861D.
MRI Nephelometer	Periodically calibrated using Freon-12 bottle. Proper flow occurred when the bottle valve was fully open.
Meloy Total Sulfur Analyzer	Periodically calibrated with an NBS permeation tube. Concentrations regulated with the Bendix 8861D.
Bendix Ozone Monitor	Calibrated periodically using ozone generated by the Bendix 8861 system.
Beckman 6800	See Section 7.2.1 for calibration procedures. Concentrations regulated with the Bendix 8861D.
Bendix 8861D	Calibration curves were developed for the flow controlling orifices of this instrument. Duplicate calibrations, performed repeatedly during the audit program, were made at all available instrument pressures on each of the five orifices using a moving bubble flow meter.
Bendix 8861P	The permeation tube assembly, consisting of a permeation tube chamber, a pressure regulator/capillary flow system, temperature control circuitry and a battery pack was subjected to repeated checks during the audit program to insure proper function.

Parameters	Calibration/Audit Standards
Sulfur Dioxide	NBS Standard Reference Materials (SRM) 1625, 1626, and 1627 were used for all audits and calibrations. Usage of a 10 cm, 5 cm, or 2 cm permeation tube was dictated by the operating range and sample flow rate of the analyzer being audited or calibrated. The source gas permeation tube was maintained at constant temperature (30.00°C ± .05°C) during use.
Nitric Oxide	NBS SRM 1684 cylinder containing 100 ppm of NO in nitrogen served as the standard. The cylinder was used either directly by quantitative dilution or it was used to certify a working standard. In the latter case, the NBS cylinder was used to calibrate an oxides of nitrogen analyzer and a vendor-supplied NO standard was then certified by analyses under identical instrument operating conditions. The working standard, NBS traceable, was used during field audits.
Nitrogen Dioxide	Nitrogen dioxide was generated by gas phase titration of nitric oxide. A constant current, constant temperature, ozone generator within the Bendix 8861 provided the ozone for the titration.
Ozone	Ozone was generated with the Bendix 8861. Concentration was routinely certified by gas phase titration of nitric oxide. The Monitor Labs 4880 NO_X Analyzer in the Winnebago was used to monitor each titration, thereby certifying the ozone concentration delivered. Both pre-audit and post-audit certifications were performed.
Total Hydrocarbons, Methane, and Carbon Monoxide	Vendor supplied cylinders certified by the EPA were normally used as standards. The standards were of such concentrations that they could be introduced directly into the analyzer without dilution. In some instances the cylinders were used to prepare audit gas samples in Teflon bags. An NBS SRM 1681 cylinder containing 1000

Parameters	Calibration/Audit Standards (continued)
	ppm CO in nitrogen was used to certify the contents of vendor supplied CO standards on some occasions. NBS hydrocarbon standards were unavailable during the study.
Zero Air	Zero air was used routinely as diluent air during the audits. The cylinders were vendor certified so that THC, CO, and NO_X concentrations were less than 10 ppb, and SO_2 concentration was less than 1 ppb. Alternate sources of zero air were sometines substituted as diluents and when this was the case the quality was verified by direct comparison to the cylinder gas. Use of these sources was limited to audits involving SO_2, NO_X, and O_3.

Location and Type of Data Available

All audit data may be found in the Task Order No. 106 final report. Calibration data for the instruments used to perform the audits, as well as for the Bendix calibration system are also included. Original data in the form of tabulations and strip charts may be obtained from the EPA Task Coordinator.

Publication

Klein, O. C., and F. E. Littman. Quality Assurance Audits. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 106 Final Report, EPA Contract 68-02-2093. January 1978.

8.3.2 EPA/EMSL STANDARDS VERIFICATION

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Funding

Regional Air Pollution Study, Program Elements 1AA003 and 1AA603
Remaining tasks funded internally by EPA/EMSL

Period of Performance 1974 - 1977

Summary

From 1974 through 1977 the Quality Assurance Branch (QAB) of the Environmental Monitoring and Support Laboratory (EMSL) was involved in various quality assurance activities related to the RAMS/RAPS program. The primary activities included the following:

1) QAB certified entire calibration systems and supplied certified standard reference materials for RAMS internal and independent audits.
2) Using RAPS funding, EMSL contracted with Research Triangle Institute (RTI) to perform an extensive on-site monitoring and auditing program of the RAMS network.
3) EMSL critically reviewed most of the quality assurance documentation generated as a by-product of RAMS.

4) EMSL and the prime contractor, Rockwell International Air Monitoring Center, analyzed numerous calibration standards and bag samples from the RAPS - St. Louis Facility.

No single report exists documenting all of the EMSL's RAPS-related activities or data. In fact, for many of the analyses memoranda containing the date of analysis, the person requesting the analysis and a general summary of the results are the only records. These memoranda are on file at EMSL. Additionally, the QAB issues monthly reports which summarize its activities, including those which were RAPS related. RTI reports on the RAMS audits are described in the Independent RAMS Quality Assurance section of this report (Section 3.2).

Location and Type of Data Available

Those individuals who are responsible for the data from the EMSL RAMS/RAPS related activities and its disposition are listed below:

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9.0 POLLUTANT EFFECTS STUDIES

Introduction

Although the quantification of pollutant effects was not an objective of RAPS, an unparalleled opportunity existed for these types of studies to be conducted, based on the availability of detailed air pollution concentration and exposure data. The experiments described in Section 9.0 include both health effects and materials effects.

The health effects studies, conducted by two universities, attempted to evaluate the role of air pollution in aggravating respiratory problems. In the materials effects studies, possible cause-effect relationships were investigated by statistically analyzing the effects data and corresponding air quality and meteorological measurements.

9.1 HEALTH EFFECTS

9.1.1 ST. LOUIS UNIVERSITY PULMONARY STUDY OF POSTAL WORKERS

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Funding EPA Contract No. 68-02-1721

Period of Performance March - December 1975

Summary

The overall purpose of this study and the following two studies (Sections 9.1.2 and 9.1.3) was to assess the relationship of exposure in adults to ambient sulfur dioxide (SO_2), total sulfur (TS), nitrates (NO_3), nitrous oxide (NO), ozone (O_3), and total hydrocarbons (THC) with lung function measurements.

This study made daily measurements of lung functions in the healthy lungs of seventeen non-smoking, male letter carriers, ages 30-45. Both their homes and work locations were encompassed by the RAMS air monitoring network. The study was conducted for 48 work days from March 31 through May 28, 1975.

Prior to the study, a preliminary examination was conducted of each subject which included a comprehensive interview, anthropometric measurements, and clinical pulmonary function testing (PFT) including body plethysmography.

During the study, at the termination of each postman's work day, six days a week for eight weeks, an interview concerning symptom status and a PFT was conducted.

Finally, at the conclusion of the study, the investigators performed a terminal examination of the subjects, duplicating the preliminary examination.

Peak levels of air pollutants monitored at RAMS Sites 101, 105, 106, 107, and 111 during the mail delivery hours were provided to the Principal Investigator by the EPA.

Findings suggest that O_3, SO_2 and TS, at the levels encountered in this study, alter the elastic properties of the lung without affecting the large or small airways. With O_3, the lungs become less compliant, while with SO_2 and TS they are more compliant. NO_2, NO and THC had no measurable effect.

All data collected have been placed on magnetic tape and forwarded to Research Triangle Park. Additional information may be obtained by contacting:

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Publication

Gill, I. S., R. H. Secker-Walker, R. G. Slavin, G. O. Broun, T. Dahms, D. Fogleman, and V. Hasselblad. Acute Effects of Air Pollutants on Healthy Outdoor Workers. St. Louis University School of Medicine, St. Louis, Missouri. Paper in preparation for American Thoracic Society.

Contract final report not submitted.

9.1.2 ST. LOUIS UNIVERSITY PULMONARY STUDY OF ASTHMATICS

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Funding EPA Contract No. 68-02-1721

Period of Performance March - December 1975

Summary

The Asthmatic Study and the Postal Worker Study (Section 9.1.1) are a combined project entitled "Serial Measurement of Pulmonary Function in Panels of Asthmatic and Occupational Groups in the St. Louis Metropolitan Area."

This study of asthmatics had the same purpose as the postman study; however, its population was eleven individuals, ages 20-63, diagnosed as having bronchial asthma. Two were non-smokers, three ex-smokers and three present smokers.

The study was conducted for 40 work days from October 1 through November 30, 1975. Study procedures were the same as for the Postal Worker Study including preliminary, daily and terminal examination of subjects accompanied by pulmonary function tests.

All data collected have been placed on magnetic tape and forwarded to Research Triangle Park. Additional information may be obtained by contacting:

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Publication

Contract final report not submitted.

9.1.3 ST. LOUIS UNIVERSITY PULMONARY STUDY OF GARDENERS

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Funding EPA Grant No. R805006-010

Period of Performance September 1976 - May 1979

Summary

Evolving from the Postal Worker and Asthmatic Studies (Sections 9.1.1 and 9.1.2), this study made daily lung function measurements of outdoor gardeners at the Missouri Botanical Garden (Shaw's Garden).

This group was advantageous since the gardeneres spend more time outdoors than the previously studied letter carrier group and because the pollutant measurements were taken from RAMS Site 106 which is located on the immediate premises.

The study was conducted for 21 work days from October 20 through November 17, 1976 and for 40 work days from May 2 through June 24, 1977.

Nineteen gardeners participated in the fall testing period and fifteen remained and were tested in the spring.

Study procedures were the same as for the Postal Workers and Asthmatic Studies including preliminary, daily and terminal examination of subjects accompanied by pulmonary function tests.

All data collected have been placed on magnetic tape and forwarded to Research Triangle Park. St. Louis University is completing data analysis and is due to present study results in May 1979. Additional information may be obtained by contacting the EPA Project Officer.

Publication

Grant final report in preparation.

9.1.4 HARVARD UNIVERSITY EPIDEMIOLOGICAL STUDY

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Funding HEW/NIEHS Grant No. ES01108

Period of Performance June 1974 - Ongoing

Technical Approach

"The Epidemiological Study on the Respiratory Health Effects of SO_2, Respiratory Particulates, and Sulfates" is the full title of this unique 10-year study. Initiated in 1974, it approaches the health effects of air pollution from an epidemiological standpoint. More specifically, it is a two-pronged study designed to measure pollutant levels in the complete environment while assessing the effects of measured pollutant levels on chronic respiratory symptoms and changes in pulmonary function in children and adults.

Six communities, with varying known pollution levels, were selected for the study involving 1400-1800 adults and 1600-2400 children in each community. The six communities are: the southeastern corner of St. Louis, Missouri; Watertown, Massachusetts; Kingston-Harrington, Tennessee; Steubenville, Ohio; Topeka, Kansas; and Portage, Washington.

The southeastern corner of St. Louis is defined in the study as a high pollution level community. It is largely residential and commercial with several nearby pollution sources including a coke plant, titanium pigment plant and a sludge incinerator. At the onset of the study, city monitoring in this area showed numerous violations of the 24-hour standards, with annual average sulfur dioxide concentrations of 110 $\mu g/m^3$ and total suspended particulate concentrations of 137 $\mu g/m^3$. Sulfate particulates were at the suggested health effects level of 12 $\mu g/m^3$.

Health effects assessment data are collected using questionaires and lung function measurement tests. Questionaires document respiratory symptoms and factors other than air pollutants that influence lung disease, such as smoking, age, heredity and other socio-economic forces. Simple pulmonary function tests are performed by trained non-medical interviewers on a low resistance, low inertial water filled recording spirometer. Adults are tested every 3 years and children annually. The first adult testing in St. Louis was in fall/winter 1975.

Air quality is being measured by three different means. These are continuous fixed location sampling, indoor/outdoor monitoring and personal monitoring.

In St. Louis, the fixed locations are at the RAMS Site 111 and at the City Monitoring Site 2 at Broadway and Hurck. Concentrations of SO_2, TSP, mass respirable particles (MRP), NO_2 and O_3 are measured continuously in addition to meteorological parameters.

Fixed site data offer comparison of pollution levels among the six cities and also serve as a reference point for the SO_2 bubblers and MRP and TSP samplers located throughout the community.

The indoor/outdoor monitors at 10 selected St. Louis homes help develop a relationship between ambient and indoor pollution levels. Concentrations of SO_2, NO_2, and MRP are measured simultaneously within the house and directly outside of it for 24 hours every 6 days. Indoor samples are taken in the room in the home where the family spends the most time (excluding bedrooms, kitchens, and bathrooms). The outdoor sampling network will supplement the fixed location monitoring.

Personal monitoring is an attempt to measure directly the pollution exposure of individuals within the community. For three days per week, volunteers carry a monitor with them over a 6-8 week period collecting a 24-hour integrated sample of MRP and water soluble sulfates while they travel throughout the community. The volunteer records his activities on each sampling day. A similar monitor is placed in the home to sample the indoor environment. As of this writing, no personal monitors have been operational in St. Louis.

Personal monitoring will allow for comparison of exposure at home to those levels encountered during a normal day's activities and for another assessment of fixed stations' representativeness for an individual who moves about the community.

Period of Data Collection (in St. Louis) 1975 - Ongoing

Parameters Measured	Instrument/Method Used
Fixed Stations	
Sulfur Dioxide, Nitrogen Dioxide, Ozone, Total Suspended Particulates, and Mass Respirable Particles	For details of instruments used and calibration/quality control procedures at RAMS Site 111 and City Site 2 refer to sections 3.0 and 10.2.1 respectively.
Indoor/Outdoor Monitors	
Total Mass Respirable Particles (under 5.0 μm)	Mine Safety Appliance (MSA) particle size analyzer cyclone, segregating particles at 5.0 μm. Particles smaller than 5.0 μm are collected on a Teflon filter and weighed to determine total mass. Flow rate is recorded when the clean filter is installed and when the exposed filter is removed.
Sulfur Dioxide and Nitrogen Dioxide	Homemade bubbler utilizing the West-Gake method for SO_2 concentrations and the Saltzman method for NO_2 analyses.

Parameters Measured	Instrument/Method Used (continued)
Indoor/Outdoor Monitors	
	Flow rate is recorded at the beginning and end of the sampling period.
Personal Monitors	
Water Soluble Sulfates and Mass Respirable Particles	(No personal monitors have been used in St. Louis as of this writing.)

Indoor/Outdoor Monitors

The cyclone and bubblers operate on identical schedules. Both actively sample from 0000-2400 CST once every six days.

Calibration and Quality Control Procedures

Indoor/Outdoor Monitors

MSA Cyclone	Rotameter calibrated every six months utilizing calibrated orifice plate and manometer.
Sulfur Dioxide and Nitrogen Dioxide Bubblers	Rotameter calibrated every six months utilizing calibrated orifice plate and manometer.

Every three months the EPA prepares a sample for laboratory analysis conducted at the Southern Illinois University - Edwardsville Campus. (Dr. Stephen Hall of SIU is under grant from Harvard to coordinate the study activities in St. Louis.) Laboratory analysis of the samples have compared favorably with the EPA's known sample concentrations.

Analysis of collected data is still in a preliminary stage. Enormous volumes of data have been generated. Data retention is vital since there is presently no certain knowledge which measure best reflects exposure.

Not too surprisingly, more respiratory symptoms and changes in pulmonary function have been detected in the dirty cities (St. Louis included). And smoking habits of participants are an overwhelming factor, making the measurement of pollutant effects on individuals who smoke extremely difficult.

All indicated trends require further analysis to standardize for smoking habits and the effects of differences in socio-economic status.

Location of Information Regarding Data Collection

For information on data collected or questions pertaining to this study contact:

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Publications

Ferris, B. G., F. E. Speizer, J. D. Spengler, D. W. Dockery, Y. Bishop, M. Wolfson, and C. Humble. A Study of the Effects of Sulfur Oxides and Respirable Particulates on the Health of Human Beings. Paper presented at the 143rd Annual Meeting of the American Association for the Advancement of Science, Denver, Colorado. February 1977.

Dockery, D. W. and J. D. Spengler. Personal Exposure to Respirable Particulates and Sulfates Versus Ambient Measurements. Paper presented at the 70th Annual Air Pollution Control Association Meeting, Toronto, Canada. June 1977.

9.2 MATERIALS EFFECTS

9.2.1 RAPS MATERIALS EXPOSURE STUDY

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Funding EPA Contract No. 68-02-1081, Task Order No. 26
EPA Contract No. 68-02-2093, Task Order No. 112

Period of Performance October 1974 - April 1977

Summary

This field study was developed to complement controlled environment chamber studies conducted by the Materials Section of the EPA in assessing the damaging effects of air pollutants on various materials. The field study was necessary to evaluate the overall agreement between laboratory results and real world damage observed and measured under ambient environmental conditions. The damaging effects of sulfur pollutants to materials is particularly important because the energy crisis may possibly bring about increased use of higher sulfur fuels. The overall knowledge resulting from both laboratory and field studies will provide important input for developing secondary air quality standards for sulfur pollutants and help establish cause-effect relationships by statistically analyzing materials effects data and corresponding air quality data.

Nine RAMS sites were selected for this study based on criteria related to monitoring of air quality data important for this exposure study and to a reasonable spread of test sites in the area covered by the RAMS network. The sites chosen were #103, 105, 106, 108, 112, 115, 118, 120 and 122.

Exposed samples were analyzed for corrosion damage with corrosion behavior observed as a function of the nature of material, exposure site and length of exposure.

Table 15 describes the materials studied, preparation of the samples, exposure conditions and methods of assessment of corrosion damage.

Parameters monitored at each test site by RAMS included:

wind speed
wind direction
temperature
dew point
sulfate and nitrate
ozone and sulfur dioxide
hydrogen sulfide
oxides of nitrogen
total sulfur
total hydrocarbon

Refer to the Regional Air Monitoring System (RAMS) (Section 3.0) for details regarding instruments operated at the RAMS sites.

Air quality data collected from each RAMS test site were received at the Science Center from the St. Louis Branch of Rockwell International Air Monitoring Center on magnetic tapes in the form of hourly averages with the exception of sulfate, nitrate and particulate matter data, which were obtained from RAPS hi-vol data at the Thousand Oaks Branch of the Air Monitoring Center.

The hourly averages received at the Science Center were further processed to produce daily and weekly averages, maxima and minima and standard deviations as discussed in the one-year and two-year reports. For the final report, only validated quarterly average data for the various exposure periods were used.

Corrosion Code Numbers (CCN) and Pollution Code Numbers (PCN) were assigned to each test site based on the average corrosion values and pollutant levels, respectively.

For the six digit CCN, the sequence of numbers corresponds to the

TABLE 15. MATERIALS, PREPARATION, EXPOSURE CONDITIONS AND ASSESSMENT OF CORROSION DAMAGE

Material	Exposure Condition	Sample Preparation	Assessment
Galvanized Steel (4" x 6" x 0.036")	30° from horizontal facing south	Degrease, clean, weigh	Gravimetric
Weathering Steel (Corten A) (4" x 6" x 0.036")	30° from horizontal facing south	Degrease, descale, weigh	Gravimetric
Al 7079-T651 (tension specimen in short transverse direction, 15 and 25 Ksi stress level)	30° from horizontal facing south	Degrease, stress	Time-to-failure
Al 2014-T651 (tension specimen in short transverse direction, 45 and 25 Ksi stress level)	30° from horizontal facing south	Degrease, stress	Time-to-failure
House Paint on stainless steel (4" x 6" x 0.036", type 3 with 2B finish)	Vertical facing north and south	Degrease, clean, apply paint, condition, weigh	Gravimetric loss of reflectance
a. oil base, 2.5 mil.			
b. latex, 1.5 mil.			
White Cherokee Marble (4" x 6" x 3/8")	30° from horizontal facing south	Clean, condition, weigh	Visual, gravimetric
Silver (6" diameter plated discs)	Open to ambient air but protected from direct environmental factors	Degrease	Visual, loss of reflectance electro-chemical
Textile-Nylon (15 denier nylon filament)	Horizontal, no protection	Stress and mount on plastic slide	Visual inspection for defects

ranking of galvanized steel, weathering steel, house paint, marble, silver and stressed aluminum alloys. In the PCN, the sequence is SO_2, TS, H_2S, O_3, NO_x, and THC. The corresponding CCN and PCN for each site are given below:

Site #	CCN	PCN
103	336652	676644
105	494431	432931
106	868977	227712
108	123223	355553
112	779799	X6X815
115	544518	111378
118	652375	X9X189
120	987856	782466
122	211134	534297

Based on the CCN, sites #108 (CCN = 123223)and #122 (CCN = 211134) are by far the most corrosive sites. For these two sites the two corresponding PCNs are 355553 and 534297 indicating average or low pollutant concentrations. On the other hand, at site #106, CCN = 868977 and PCN = 227712 indicate low corrosivity but high concentrations of SO_2, TS, NO_X and THC. A comparison of CCNs and PCNs, therefore, does not show any obvious correlations between corrosivity and pollution. It has also to be considered that high concentrations of some pollutants might have an inhibiting effect on corrosion rates.

Several experiments not included in the Task Order specifications were added to the program at various times. Since samples for the tests were provided and analyses of the results carried out by the persons who were responsible for these experiments, no additional costs were incurred. A brief summary of each program follows.

Aluminum Alloy Panels Exposed by ALCOA

At the start of the exposure test in October 1974, ALCOA personnel exposed a number of Al alloys at all nine sites to evaluate weathering of such materials and to analyze the deposits as an indicator of the pollutants present on the Al tension samples. The test panels were 4 by 6 in. in size and 0.063 in. thick. Five 2014-T6 panels and a single panel each of 1160-H14 and 7075-T6 were exposed at each site. A set of 2014-T6 panels was returned for evaluation after 3, 6, 12 and 24 months. The 1160 and 7075 panels were returned after 24 months. After visual examination, panels from sites #103, 108 and 122 were retained for further analysis while the other panels were re-exposed.

It was concluded from the results obtained by ALCOA that differences in the depth of attack at the various sites are small and not significant. As expected, pure Al panels incurred considerably less corrosion than Al 2014-T6 and 7075-T6. The rate of corrosion of Al 2014-T6 decreased markedly after the initial three months of exposure. The results of the tensile tests showed no significant reduction in tensile strength as a result of the two year exposure. There was a slight decrease in elongation as a result of notch effects from sites of corrosion. However, even this was considered to be slight and unrelated to the level of airborne pollutants.

Exposure of CLIMAT Devices

Starting in April 1976, four sets of CLIMAT (Classification of Industrial and Marine Atmospheres) devices were exposed at all nine test sites for a period of 90 days. Al wire (0.9 mm in diameter and 900 mm long) was wound on plastic, Cu or Fe bolts. Corrosion indices were calculated based on the percent weight loss of the Al wire. From the Al/nylon couple an atmospheric corrosion index (ACI) was derived, the Al/Fe couple gave the marine corrosion index (MCI), and a calculated combination of the Al/Fe and Al/Cu data provided the industrial corrosion index (ICI). Periods of no corrosion were not considered in the averages.

H. H. Lawson of ARMCO Steel Corp., Middletown, Ohio, who provided and analyzed the CLIMAT samples, reached the following conclusions:

> "Inspection of the tabular data does not indicate any particular trends with respect to the atmospheres at the sites. The significant corrosion rates, where observed, appear to be random excursions, and are scattered between the various couple indices. In general, as might be expected, the fall/winter exposures are

somewhat more severe, and the two 'extremity' sites, 118 and 122, appear to be less corrosive than the rest with respect to the CLIMAT devices. Site 120 is probably the next least corrosive site. It is difficult to determine the most severe site due to the inordinate influence of the excursions referred to earlier. However, I would be inclined to call site 105 the most severe, closely followed by 103. Sites 106 and 108 are comparable and probably the next most severe. I would rank the sites from severest to mildest as follows:

105, 103, 106, 108, 112, 115, 120, 118, 122

The St. Louis area does not seem to be particularly corrosive - at least not to Al 1100."

It will be noted that failure of 100% of all Al tension samples at 25 Kilopounds per square inch (Ksi) occurred in the shortest time at site #105 followed by #103, 122, 106 and 108. All Al 2014 samples at 25 Ksi failed only at sites #105 and 108. Failure times of the other samples also seem to be related to the CLIMAT results.

Atmospheric Weathering Test on Bronze Samples

This task was conducted by Prof. D. W. Zimmerman, Director of the Center for Archeometry of Washington University, St. Louis, Missouri.

Bronze plates were placed on the roofs of five RAMS stations in the greater St. Louis area. The purpose was to observe and measure the rates of corrosion of plates over a period of at least 2 years to provide fundamental and vital data for the University's outdoor bronze monument conservation program. Specific questions to be studied were:

1. Do wrought and cast bronzes corrode at different rates?
2. How does glass-bead peening affect the corrosion rate?
3. How does the alloy composition affect the corrosion rate?

Samples

Fourteen samples (2" x 3" x 1/4") were placed on each of the five sites. Seven samples of each of two alloys: 85% Cu, 5% Sn, 5% Zn, 5% Pb; and

89% Cu, 11% Sn, were prepared as follows:

1. Cast -- surface filed
2. Cast -- surface polished
3. Wrought -- surfaced polished
4. Wrought -- no surface treatment
5. Cast -- no surface treatment
6. Cast -- glass-bead peened
7. Wrought -- glass-bead peened

The samples were weighed before being set in place on April 15th and 16th, 1976, at sites #105, 108, 112, 120 and 122.

After one year of exposure, the results were as follows:

1. The primary effect was a darkening/tarnishing. Very little of the basic green corrosion product had formed yet - only a thin green veil over the "untreated" cast plate at site #122.
2. The 85-5-5-5 (Cu, Sn, Pb, Zn) alloy was darkening considerably faster than the 89-11 (Cu, Sn) alloy.
3. The glass bead peened (the technique used for cleaning outdoor bronze monuments) plates showed the same or less darkening than unpeened plates.
4. Areas peened a higher pressure (80-100 psi) and with larger bead size (125 μm) showed less tarnishing than lower pressure (4-60 psi) and smaller bead size (75 μm).
5. The highly polished, wrought plates showed the least tarnishing.
6. No systematic differences between the five sites were apparent.

Exposure of Atmospheric Corrosion Monitors (ACM)

The atmospheric corrosion monitor (ACM) consists of a Cu/Zn or Cu/steel couple which registers current flow when electrolyte bridges the dissimilar metal plates. The electrolyte might result from condensation of water from the air on corrosion products, from dew or from rain. It has been shown that the ACM data not only measure the time-of-wetness of a test panel, but can also determine the corrosivity of a test site. Three ACMs were installed on October 3, 1975 at sites #103, 112 and 122. Later an additional Cu/steel ACM was installed at site #106. The ACM recording was stored in the RAMS/RAPS system and the resulting data evaluated at the Science Center under an Office of Naval Research contract which deals with basic mechanisms of atmospheric corrosion.

The ACM data for all four test sites will be analyzed in terms of time-of-wetness and corrosivity of test sites and correlations between ACM data and atmospheric parameters will be attempted.

Location and Type of Data Available

All corrosion and air quality data are contained in the reports referenced below. Additional information may be obtained from the EPA Task Coordinators.

Publications

Mansfeld, F. B. Study of the Effects of Airborne Sulfur Pollutants on Materials, One-Year Exposure Report. Rockwell International Science Center, Thousand Oaks, California. Task Order No. 26 Progress Report, EPA Contract 68-02-1081. January 1976.

Mansfeld, F. B. Study of the Effects of Airborne Sulfur Pollutants on Materials, Two-Year Exposure Report. Rockwell International Science Center, Thousand Oaks, California. Task Order No. 112 Progress Report, EPA Contract 68-02-2093. May 1977.

Mansfeld, F. B. Study of the Effects of Airborne Sulfur Pollutants on Materials. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 112 Final Report, EPA Contract 68-02-2093. September 1979.

10.0 LOCAL POLLUTION MONITORING NETWORKS

Introduction

Included in Section 10.0 are descriptions of local pollution monitoring networks operated in the RAPS study area by state agencies, by city and county agencies, and by private industry. These networks are important to the RAPS for two reasons.

First, RAPS researchers may use these data to augment their own measurements obtained in the St. Louis area. Secondly, these networks provide a reference base or benchmark for the RAMS network, enabling past and future extrapolation of air quality trends, as well as serving as a mechanism for cross-checking simultaneous RAMS measurements.

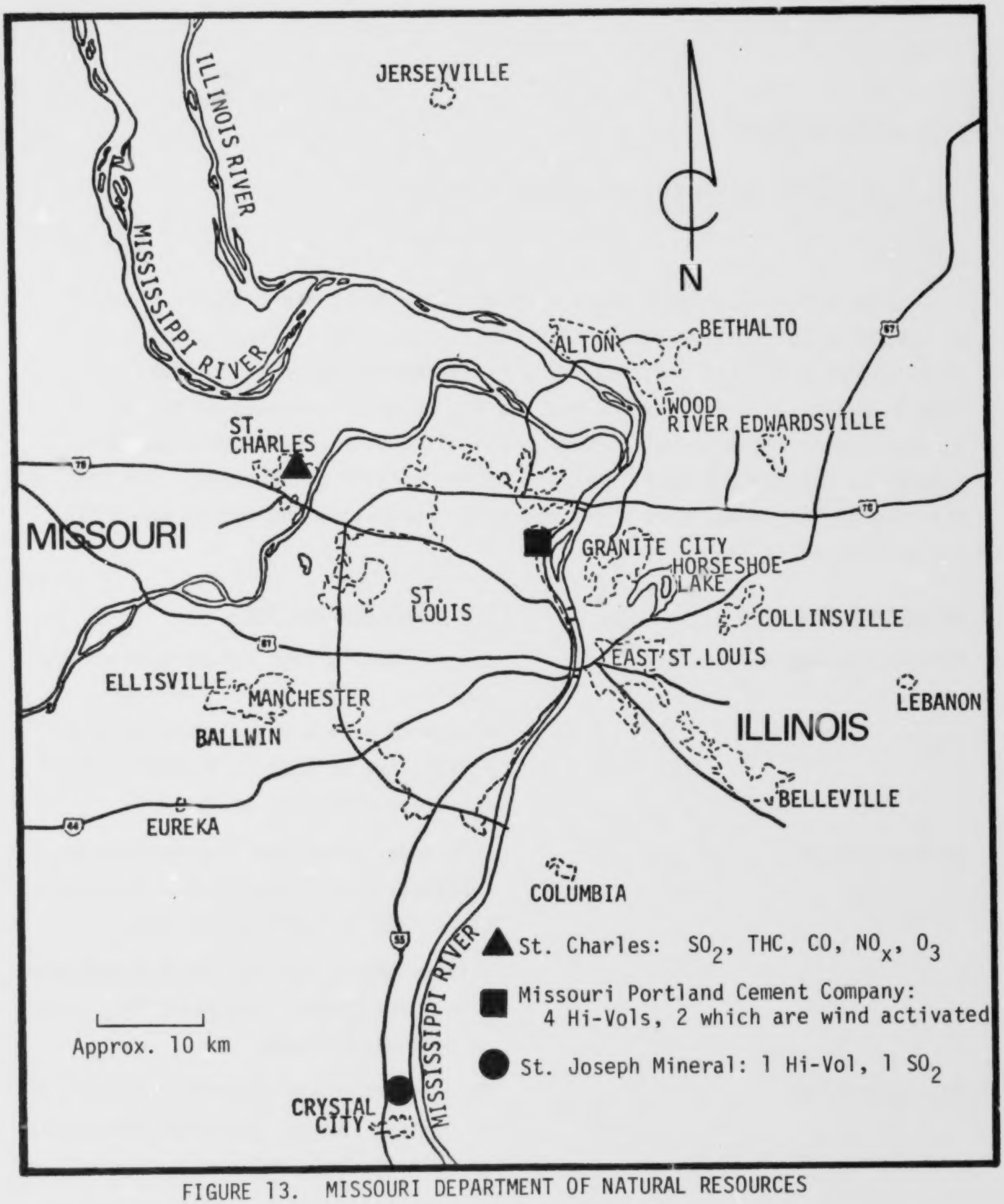
10.1 STATE AGENCIES

10.1.1 MISSOURI DEPARTMENT OF NATURAL RESOURCES

Location

Three air monitoring sites are being operated by the Missouri Division of Environmental Quality in the RAPS study area. Two of these sites are point source pollutant monitors. One is located at the Missouri Portland Cement Company in Riverview Gardens and the other is situated at the St. Joseph Mineral Plant in Herculaneum. The third site continuously samples ambient air in the northwest quadrant of the city of St. Charles. The spatial distribution of these three sites and their respective monitoring capacities are delineated in Figure 13.

Parameters Measured	Instrument/Method Used
Total Suspended Particulates	General Metals high volume particulate samplers. Flow rate is continuously monitored with a Dixon chart recorder. Filters are weighed to determine total mass concentrations only.
Sulfur Dioxide	TECO Model 43 pulsed fluorescence SO_2 analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm.
	Philips Model 7500 coulometric analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm.
Nitrogen Oxides	TECO 14B chemiluminescence analyzer, 0 to 0.5 ppm range. Concentrations read to nearest 0.01 ppm.



▲ St. Charles: SO_2, THC, CO, NO_x, O_3

■ Missouri Portland Cement Company: 4 Hi-Vols, 2 which are wind activated

● St. Joseph Mineral: 1 Hi-Vol, 1 SO_2

FIGURE 13. MISSOURI DEPARTMENT OF NATURAL RESOURCES AIR MONITORING SITES

Parameters Measured	Instrument/Method Used (continued)
Ozone	Monitor Labs 8410 chemiluminescence ozone analyzer, 0 to 0.2 ppm range. Concentrations read to nearest 0.01.
Carbon Monoxide	Beckman 365 nondispersive infrared analyzer, 0 to 50 ppm range. Concentrations read to nearest 0.10 ppm.
Total Hydrocarbons	Bendix A201 flame ionization total hydrocarbon analyzer, 0 to 10 ppm range. Concentrations read to nearest 1.00 ppm.

Observation Interval

All of the total suspended particulate samplers were operational prior to 1972. The Philips SO_2 analyzer at the Herculaneum location has been operational since 1973. All instruments at the St. Charles site have been operational since 1972. The Monitor Lab 8410 O_3 analyzer was removed in 1975. The Bendix A201 hydrocarbon analyzer, Beckman 365 CO sampler, and TECO 14B NO_X sampler were removed in 1976. The TECO model 43 was phased out in September 1977. The phaseout was due to the very low pollutant concentrations being registered.

Total Suspended Particulates	All high volume particulate samplers, with the exception of two at the Portland Cement Company, sample at six day intervals with an active sampling interval from 0000-2400 CST. The two at the Missouri Portland site are activated when the wind is within 7-1/2 degrees of due south.
Gaseous Pollutant Samplers	All instruments sample continuously.

Calibration and Quality Control Procedures

General Metals Particulate Sampler	The flow meters are calibrated three times a year. A calibrated orifice plate and a manometer are used for field

Calibration and Quality Control Procedures (continued)

	calibrations. The calibrations are performed biannually by the Missouri Department of Natural Resources and annually by the EPA.
TECO Model 43 and Philips Model 7500 SO_2 Analyzers	Zero and multipoint calibrations are performed once every three months. An NBS permeation tube with a Meloy dilution system is used during the calibration process.
TECO 14B NO_X Analyzer	Zero and span calibrations are performed every three months. A Scott Research NO cylinder with a concentration of approximately 5 ppm, traceable to an NBS standard, is used in conjunction with an NBS NO_2 permeation tube with a Meloy dilution system for the calibration process.
Monitor Labs 8410 O_3 Analyzer	Zero and multipoint calibrations are once every three months. A modified Scientific Products ozone generator is calibrated against a Dasibi O_3 analyzer in the laboratory and then used for the field calibrations.
Beckman 365 CO Analyzer	Zero and multipoint calibrations are performed once every three months. A Scott Research CO cylinder is compared to an NBS standard at the laboratory and used for field calibrations.
Bendix A201 Hydrocarbon Analyzer	Zero and multipoint calibrations are performed every three months. A dilute Scott Research propane cylinder is used for field calibration processes.

Instrument Location

The locations of the gaseous pollutant monitoring and hi-vol sites and their respective instrumentation are represented in Figure 13.

Location and Type of Data Available

All raw data generated in the field, excluding the hi-vols, are recorded on strip chart and reduced at the State Office. Data are available on magnetic tape in SAROAD format from the Department of Natural Resources, Division of Environmental Quality in Jefferson City, Missouri. These data are also submitted to the EPA Region VII office in Kansas City, Missouri, who in turn submit them to the National Aerometric Data Bank (NADB) at Research Triangle Park.

To acquire data from the Missouri Department of Natural Resources contact:

Randy Raymond
Department of Natural Resources
Air Quality Section
2010 Missouri Boulevard
Jefferson City, MO 65101

(314) 751-3241

For data from the National Aerometric Data Bank contact:

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Location of Information Concerning Data Collection

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10.1.2 ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

Location

The Illinois Environmental Protection Agency (IEPA) operates 18 air monitoring sites in Madison, St. Clair and Monroe counties. The locations of the various sampling sites are shown in Figure 14 and the instrumentation contained at each site is annotated in Table 16.

Parameters Measured	Instrument/Method Used
Sulfur Dioxide	Philips 9700 coulometric SO_2 analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm.
	Technicon Model IV colorimetric SO_2 analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm.
	Pedco NO_2/SO_2 bubbler sampling once every six days and analyzed by a Technicon automated analyzer. SO_2 concentrations are expressed in parts per million. Concentrations read to nearest 0.01 ppm.
Nitrogen Oxides	TECO 14B NO/NO_2 chemiluminescence analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm.
	Pedco NO_2/SO_2 bubbler sampling once every six days and analyzed by a Technicon automated analyzer. NO_2 concentrations are expressed in parts per million. Concentrations read to nearest 0.001 ppm.

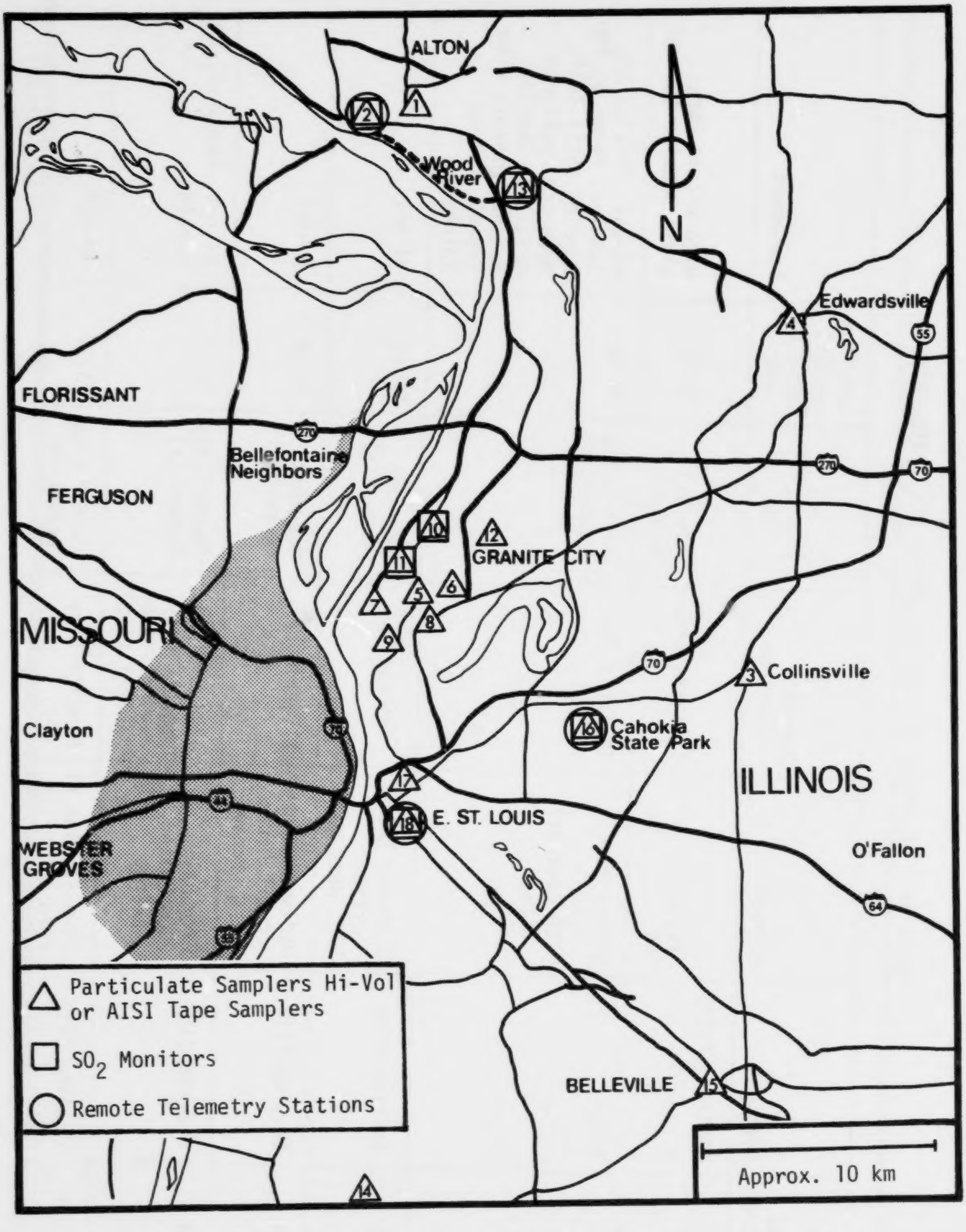

FIGURE 14. ILLINOIS EPA AIR POLLUTION MONITORING SITES

TABLE 16. ILLINOIS EPA AIR POLLUTION MONITORING SITES

Map Location	Station	Address	Owner/ Operator	Station Type	Sampling Height (meters) AGL	Equipment
	Madison County					
1	Alton	City Hall 103 E. 3rd St.	Illinois EPA	Suburban Industrial	9.75	High Volume Particulate Sampler (hi-vol)
2	Alton	Horace Mann School 2708 Edwards Street	Illinois EPA	Center City Residential	15.24	Hi-vol, Philips SO_2 Sampler, Pedco SO_2/NO_2 Bubbler until 1976, Research Appliance AISI Tape Sampler, Weather Measure Wind System, Remote Telemetry
3	Collinsville	Illinois EPA Office 115A West Main	Illinois EPA	Suburban Commercial	12.13	Hi-vol
4	Edwardsville	Madison County Court House 132 N. Kansas	Illinois EPA	Suburban Commercial	15.24	Hi-vol
11	Granite City	City Hall 2000 Edison Avenue	Illinois EPA/ Granite City Air Pollution Control (APC)	Center City Industrial	12.13	Hi-vol, Pedco SO_2/NO_2 Bubbler
8	Granite City	Fire Station #1 23rd & Madison	Granite City APC	Center City Industrial	13.72	Hi-vol

(continued)

TABLE 16 (continued)

Map Location	Station	Address	Owner/ Operator	Station Type	Sampling Height (meters) AGL	Equipment
	Madison County	(continued)				
6	Granite City	Lake School 3201 East 23rd	Granite City APC	Suburban Industrial	4.27	Hi-vol
5	Granite City	2001 East 20th	Granite City APC	Center City Industrial	4.57	Hi-vol, Research Appliance AISI Tape Sampler as of 6/15/76
9	Granite City	15th & Madison	Granite City APC	Center City Industrial	4.57	Hi-vol
7	Granite City	Fire Station #2 Roosevelt and Rock Road	Granite City APC	Suburban Industrial	5.49	Hi-vol
10	Granite City	Granite City APC Office 2301 Adams	Granite City APC	Suburban Industrial	10.67	Research Appliance Tape AISI Sampler, Technicon SO_2 Sampler, Weather Measure Wind System, Strip Chart Recorders
12	Granite City	Frohardt School 2040 Johnson	Illinois EPA/ Granite City	Suburban Residential	6.10	Hi-vol

(continued)

TABLE 16 (continued)

Map Location	Station	Address	Owner/ Operator	Station Type	Sampling Height (meters) AGL	Equipment
	Madison County	(continued)				
13	Wood River	Water Treatment Plant 54 Walcott	Illinois EPA	Suburban Industrial	4.57	Hi-vol, Research Appliance AISI Tape Sampler, Bendix UNOR-5 CO Sampler, Weather Measure Wind System, Dasibi O_3 Analyzer, Technicon SO_2 Analyzer, PEDCO SO_2/NO_2 Bubbler, Remote Telemetry
	Monroe County					
14	Columbia	City Hall 208 South Rapp	Illinois EPA	Suburban Commercial	9.14	Hi-vol
	St. Clair County					
15	Belleville	City Hall 101 S. Illinois	Illinois EPA	Suburban	9.14	Hi-vol
16	Cahokia State Park	Business Route 40	Illinois EPA	Suburban Commercial	4.57	Hi-vol, Research Appliance AISI Tape Sampler, Bendix UNOR-5 CO Sampler, Technicon SO_2 Analyzer, Dasibi O_3 Analyzer, Litton Wind System and

(continued)

TABLE 16 (continued)

Map Location	Station	Address	Owner/ Operator	Station Type	Sampling Height (meters) AGL	Equipment
	St. Clair County	(continued)				Meteorology Package (Temperature, Atmospheric Pressure, Rainfall, Solar and UV Radiation). TECO NO_x Analyzer, Remote Telemetry.
17	East St. Louis	City Hall 7 Collinsville Avenue	Illinois EPA/ East St. Louis City	Center City Industrial	15.24	Hi-vol
18	East St. Louis	Federal Bldg. 650 Missouri	Illinois EPA	Center City Industrial	18.29	Philips SO_2 Analyzer, Research Appliance AISI Tape Sampler, Bendix UNOR-5 CO Analyzer, Weather Measure Wind System, Dasibi O_3 Analyzer, PEDCO SO_2/NO_2 Bubbler, Remote Telemetry

Parameters Measured	Instrument/Method Used (continued)
Ozone	Dasibi Model 10003 AH ultraviolet absorption ozone analyzer, 0 to 0.5 ppm range. Concentrations read to nearest 0.01 ppm.
Carbon Monoxide	Bendix UNOR-5 nondispersive infrared CO analyzer, 0 to 50 ppm range. Concentrations read to nearest 0.10 ppm.
Coefficient of Haze	Research Appliance Corporation AISI tape sampler measuring the coefficient of haze.
Wind Direction and Speed	Weather Measure and Litton wind systems indicating direction in degrees of azimuth corrected to true north and speed in miles per hour.
Total Suspended Particulates	General Metals high volume particulate sampler. Flow rate is recorded when the clean filter is installed, and when the exposed filter is removed. Flow rate during a sampling interval is the average of these readings.
Meteorology Monitoring Package including Temperature, Rainfall, Ultraviolet and Solar Radiation, and Atmospheric Pressure	The site located at Cahokia Mounds State Park has a Litton meteorological package containing a thermistor, recording in °C and an Epply ultraviolet radiometer and a solar pyranometer measuring Langleys per minute. Also operational are a Sostman model 201-4 barometer measuring millimeters of mercury and a MRI tipping bucket rain gauge measuring rainfall to the nearest hundredth of an inch.

Observation Interval

Instantaneous values for all parameters at remote telemetry sites are transmitted at five minute intervals to the central computer complex at IEPA offices in Springfield, Illinois. These are then recorded and averaged on an hourly basis. The hi-vol samplers and the NO_2/SO_2 bubblers sample once every six days from 0000 to 2400 CST and their data are retrieved manually. The AISI coefficient of haze instruments sample continuously. The paper tape is advanced and readings are made at two hour intervals. All locations were operational prior to 1972.

Calibration and Quality Control Procedures

Philips 9700 SO_2 Analyzer	A zero and span check is performed daily. Monthly calibrations are performed using an NBS traceable permeation tube and a Monitor Lab 8500 dilution system.
Technicon Model IV SO_2 Analyzer	A zero and span check is performed daily. A monthly calibration is performed using an NBS traceable permeation tube and a Monitor Lab 8500 dilution system. Permeation tube temperature is oven controlled.
PEDCO NO_2/SO_2 Bubbler	Equipment is cleaned and calibrated every six days when sample is retrieved.
TECO 14B NO_x Analyzer	Zero and multipoint calibrations are performed once every three months. An Airco NO cylinder traceable to an NBS standard and an NBS NO_2 permeation tube with a Meloy dilution system are used for the calibration procedure.
Dasibi Model 10003 Ozone Analyzer	An electrical zero and span is performed daily. A TECO ultraviolet ozone generator is employed for total calibration once every six months.

Calibration and Quality Control Procedures (continued)

Bendix UNOR-5 CO Analyzer	The instrument undergoes a weekly manual zero and span check and receives a monthly calibration using an NBS standard bottled gas.
Research Appliance AISI Tape Sampler	No calibration is performed on this particular piece of equipment.
Weather Measure and Litton Wind Systems	Since 1973, wind speed data are checked weekly for anomalies. A constant RPM motor is utilized for the yearly calibration. Directional alignment is performed on a yearly basis employing solar noon as an orientation point.
General Metals Particulate Samplers	The flow meters are calibrated bi-annually utilizing a Rootsmeter calibrated orifice plate and a manometer.
Litton Meteorology Package	Every three years the whole unit is shipped to Litton for recalibration. The last calibration was implemented in 1974.

All data produced are visually examined for obvious anomalies. For remotely telemetered data at least three valid readings per hour must be acquired before the data are recorded. Slope and drift for the instruments are calculated and programmed.

Instrument Location

The locations of the instruments are shown in Figure 14 and described in Table 16.

Location and Type of Data Available

Data are available on magnetic tape, micro-fiche and as hard copy. All data generated by IEPA are routed through EPA Region V headquarters in Chicago and eventually are filed in the NADB at Research Triangle Park. Data quality has improved since 1975 with the implementation of quality control procedures. All data are in SAROAD format.

For further information on data availability contact:

Robert Swinford
Illinois Environmental Protection Agency
Division of Air Pollution Control
2200 Churchill Road
Springfield, IL 62706

(217) 782-5811

For data from the National Aerometric Data Bank contact:

Christopher Timm
Environmental Protection Agency, Region V
Surveillance and Analysis Division
230 South Dearborn
Chicago, IL 60604

(312) 353-2000

Location of Information Concerning Data Collection

Robert A. Arnott
Manager, Ambient Air Monitoring Section
Illinois Environmental Protection Agency
Division of Air Pollution Control
2200 Churchill Road
Springfield, IL 62706

(217) 782-5811

10.2 CITY AND COUNTY AGENCIES

10.2.1 CITY OF ST. LOUIS POLLUTION CONTROL NETWORK

Location

Ten air monitoring sites are located in the city of St. Louis (Figure 15). All continuous sampling sites are monitored remotely and recorded at a central computer terminus located at the corner of Clark and Twelfth Streets.

Parameters Measured	Instrument/Method Used
Wind Direction and Speed	Xonics anemometer and directional vane. Speed is recorded in miles per hour and direction in degrees of azimuth corrected to true north.
Ambient Temperature	Xonics forced ventilation radiation shielded thermistor, reported in degrees Fahrenheit.
Sulfur Dioxide	Davis 11-7010 RP conductimetric SO_2 analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm. TECO Model 43 pulsed fluorescence SO_2 analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm.
Nitrogen Oxides	Meloy NA-520-2 chemiluminescent analyzer, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm. Beckman K-78 colorimetric acrylizer converted from Lyshkow reagent to Saltzman reagent in December 1972, 0 to 1 ppm range. Concentrations read to nearest 0.01 ppm.

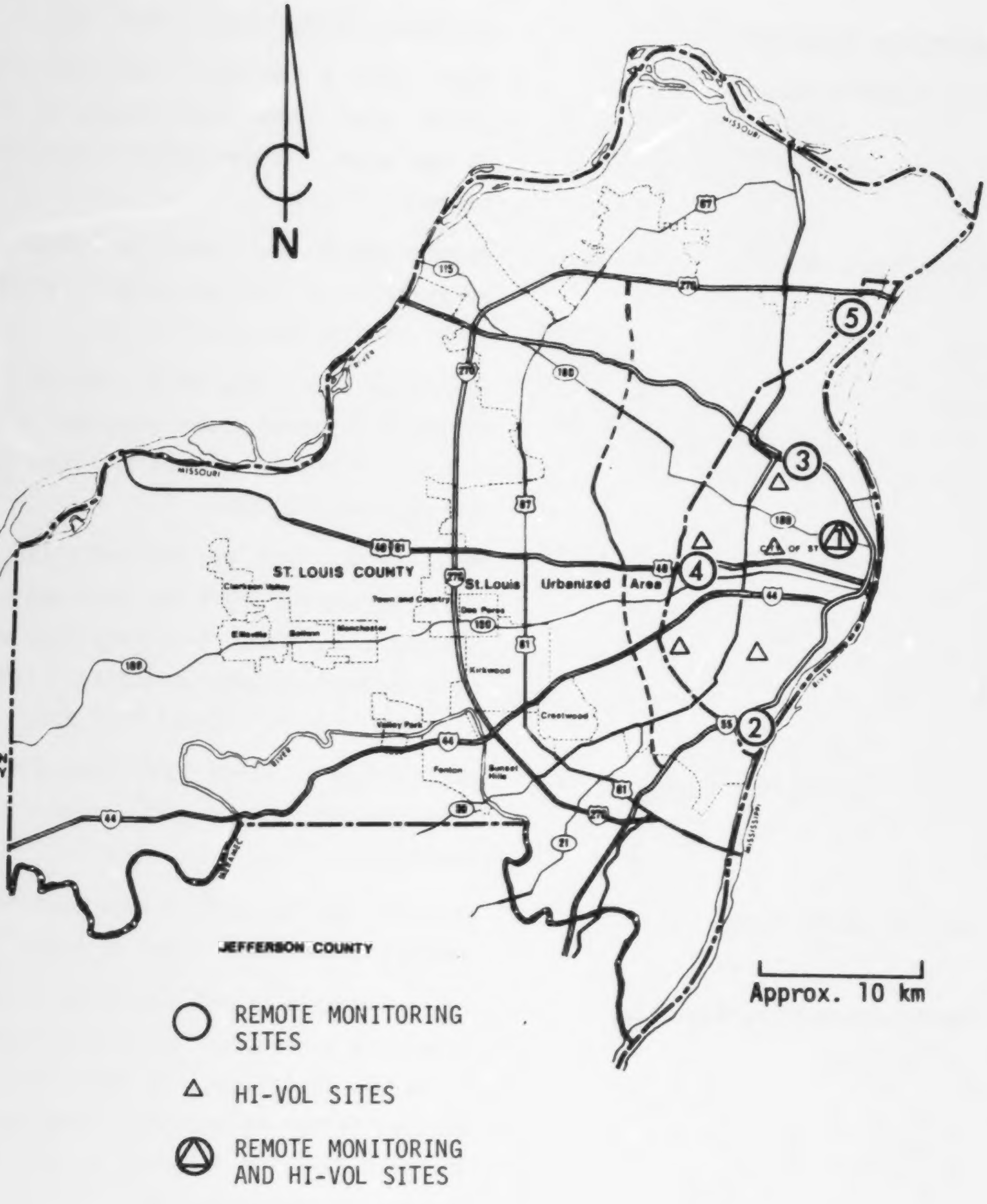

FIGURE 15. ST. LOUIS CITY REMOTE MONITORING AND HI-VOL SITES

Parameters Measured	Instrument/Method Used (continued)
Total Hydrocarbons	Bendix 8401 and Beckman 108A flame ionization total hydrocarbon analyzers, 0 to 20 ppm range. Concentrations read to nearest 0.1 ppm.
Carbon Monoxide	Beckman 315 BL nondispersive infrared analyzer, 0 to 100 ppm range. Concentrations read to nearest 0.1 ppm.
Ozone	McMillian 1100-2 and Bendix 800-02 chemiluminescence ozone analyzer, 0 to 0.5 ppm range. Concentrations read to the nearest 0.01 ppm. Prior to May 1975 for the McMillian analyzer and May 1974 for the Bendix analyzer, a Beckman K-78 acrylizer was used to measure total oxidants. Concentrations read to nearest 0.01 ppm.
Aerosol Backscatter	Meteorology Research 1550 integrating nephelometer measuring the scattering coefficient.
Coefficient of Haze	Research Appliance AISI tape sampler measuring the coefficient of haze.
Total Suspended Particulates	General Metals hi-vol particulate sampler. Flow rate is recorded when the clean filter is installed, and when the exposed filter is removed. Flow rate during a sampling interval is the average of these readings.

Observation Interval

All remote telemetry data are recorded instantaneously every three minutes for each parameter by an onsite data acquisition system. This system transmits fifteen minute averages to the central computer of the

City of St. Louis Pollution Control Office. The fifteen minute averages are further reduced to hourly averages at the central computer complex. The hi-vols sample once every six days from 0000-2400 CST. The AISI tape samplers operate continuously and record at two hour intervals. All hi-vols were operational prior to 1972. Periods of operation for remote monitoring sites are annotated in Table 17.

Calibration and Quality Control Procedures

Xonics Anemometer and Directional Vane	The only calibration is done at factory prior to installation.
Xonics Forced Ventilation Thermistor	Original calibration occured in June 1973. Readings are compared daily to NWS information. If a discrepancy of greater than ± 2.0°F occurs, the sensor is recalibrated.
Davis 11-7010 and TECO Model 43 SO_2 Analyzer	A Mylar bag sample of SO_2 with a concentration determined by the Federal Reference Method (Pararosaniline Technique) is used for calibration. Calibration has been done monthly since 1973. Prior to 1973, calibration occurred about once every 3 months.
Beckman K-78 Acrylizer NO_X Analyzer	Static color calibration and span calibrations are performed once every six months. A cylinder of Airco NBS traceable NO is used in conjunction with a homemade ozone generator for NO and NO_2 calibrations. Concentrations of the combined gases were determined by gas phase titration.
Meloy NA 520-2 NO_X	Static color calibration and span calibrations are performed once every six months. A cylinder of Airco NBS traceable NO is used in conjunction with a

TABLE 17. CITY OF ST. LOUIS REMOTE TELEMETRY STATION EQUIPMENT

STATION	WIND DIRECTION	WIND SPEED	AMBIENT TEMPERATURE	SULFUR DIOXIDE	NITROGEN DIOXIDE	NITROGEN OXIDE	TOTAL HYDROCARBONS	CARBON MONOXIDE	OZONE	LIGHT SCATTERING COEFFICIENT	COEFFICIENT OF HAZE
1	Xonics Directional Vane 1972-1977	Xonics Three Cup Anemometer 1972-1977	Xonics Shielded Thermistor 1972-1977	Davis 1972-4/1977 TECO 4/1977-1977	Beckman 1972-7/1975 Meloy 7/1975-present	Beckman 1972-7/1975 Meloy 7/1975-present	Beckman Flame Ionization 1972-1977	Beckman Non-dispersive Infrared 1972-1977	Beckman Total Oxidant 1972-6/1975 McMillen 6/1975-1977	MRI Integrating Nephelometer 1972-1977	AISI Research Appliance Corporation
2	Xonics Directional Vane 1972-1977	Xonics Three Cup Anemometer 1972-1977	Xonics Shielded Thermistor 1972-1977	Davis 1972-12/1976 TECO 12/1976-1977	Beckman 1972-1977	Beckman 1972-1977	Bendix Flame Ionization 1972-1977	Beckman Non-dispersive Infrared 1972-1977	Beckman Total Oxidant 1972-6/1975 McMillen 6/1975-1977	MRI Integrating Nephelometer 1972-1977	AISI Research Appliance Corporation
3	Xonics Directional Vane 1972-1977	Xonics Three Cup Anemometer 1972-1977	Xonics Shielded Thermistor 1972-1977	Davis 1972-1977	Beckman 1972-1977	Beckman 1972-1977	Bendix Flame Ionization 1972-1977	Beckman Non-dispersive Infrared 1972-1977	Beckman Total Oxidant 1972-6/1974 Bendix 6/1974-1977	MRI Integrating Nephelometer 1972-1977	AISI Research Appliance Corporation
4	Xonics Directional Vane 1972-1977	Xonics Three Cup Anemometer 1972-1977	Xonics Shielded Thermistor 1972-1977	Davis 1972-5/1977 TECO 5/1977-present	Beckman 1972-1977	Beckman 1972-1977	Beckman Flame Ionization 1972-1977	Beckman Non-dispersive Infrared 1972-1977	Beckman Total Oxidant 1972-6/1975 McMillen 6/1975-1977	MRI Integrating Nephelometer 1972-1977	AISI Research Appliance Corporation
5	Xonics Directional Vane 1972-1977	Xonics Three Cup Anemometer 1972-1977	Xonics Shielded Thermistor 1972-1977	Davis 1972-5/1977 TECO 5/1977-present	No Equipment	Beckman 1972-1977	Beckman Flame Ionization 1972-1977	Beckman Non-dispersive Infrared 1972-1977	Beckman Total Oxidant 1972-6/1975 McMillen 6/1975-1977	MRI Integrating Nephelometer 1972-1977	AISI Research Appliance Corporation

Calibration and Quality Control Procedures (continued)

	homemade ozone generator for NO and NO_2 calibrations. Concentrations of the combined gases were determined by gas phase titration.
Beckman 108A and Bendix 8401 Total Hydrocarbon Analyzers	The Beckman and Bendix equipment are zero checked daily and calibrated monthly using dilute propane span gas.
Beckman 315 BL Infrared CO Analyzer	The instrument is zero checked daily and calibrated monthly using a dilute NBX traceable span gas.
McMillian 1100-2 and Bendix 800-02 Ozone Analyzers	Both instruments contain an internal ozone source which is used for monthly calibrations. A more precise portable ozone generator with the ozone output calibrated in the laboratory by the neutral buffered Potassium Iodide method is used for field calibrations once every six months.
MRI 1550 Integrating Nephelometer	Calibration using Freon 12 is performed only when anomalies appear in aerosol data.
General Metals High Volume Particulate Sampler	The flow meter is calibrated once every four months using a Rootsmeter calibrated orifice plate and manometer.
AISI Tape Sampler	No calibration is performed on this equipment.

Quality control operations are performed daily on the data produced by the remote telemetry sites. All parameters are visually checked for anomalies on the computer printout. Any apparent discrepancies are rechecked to assure the validity of the data.

Instrument Location

The locations of the remote monitoring and hi-vol sites are represented in Figure 15. The instrumentation contained at each remote monitoring site is delineated in the Table 17.

Location and Type of Data Available

All data are available on magnetic tape in SAROAD format. Data generated by the city of St. Louis are provided to the Missouri Department of Natural Resources for state archiving. They are then forwarded to the EPA Region VII office in Kansas City, Missouri for filing at the NADB at Research Triangle Park. Prior to 1972 all data quality is doubtful due to the lack of quality control and standardization procedures. Subsequent to 1972 data quality improves.

A programming error existed which was not discovered until 1976. This involves all NO and NO_X data for December 1975 - December 1976. All data for this time interval has been invalidated. Raw data are available for the other time periods. Data are available from W. L. Hagar (address below).

For data from the National Aerometric Data Bank contact:

Rowena Micheals
Environmental Protection Agency, Region VII
324 East 11th Street
Kansas City, MO 64106

(816) 374-5493

Location of Information Concerning Data Collection

W. L. Hagar
St. Louis City Division of Air Pollution Control
419 City Hall
St. Louis, MO 63103

(314) 453-3334

10.2.2 ST. LOUIS COUNTY AIR POLLUTION CONTROL BOARD

Location

Eleven air monitoring sites are located in St. Louis County. The spatial distribution and instrumentation of the respective sites are delineated in Figure 16.

Parameters Measured	Instrument/Method Used
Wind Direction and Speed	Litton three cup anemometer and directional vane indicating speed in miles per hour and direction in degrees of azimuth oriented to magnetic north.
Ambient Temperature	Litton thermistor indicating in degrees Fahrenheit.
Sulfur Dioxide	Technicon Model 1 colormetric analyzer, 0 to 0.5 ppm range. Concentrations read to the nearest 0.01 ppm. Meloy SA-125 flame photometric analyzer, 0 to 0.5 ppm range. Concentrations read to the nearest 0.01 ppm.
Nitrogen Oxides	Technicon Model 1 colorimetric analyzer, 0 to 0.5 ppm range for NO and 0 to 0.2 ppm range for NO_2. Concentrations read to the nearest 0.01 ppm. Thermo Electron chemiluminescent NO_X analyzer, 0 to 1 ppm range. Concentrations read to the nearest 0.01 ppm.

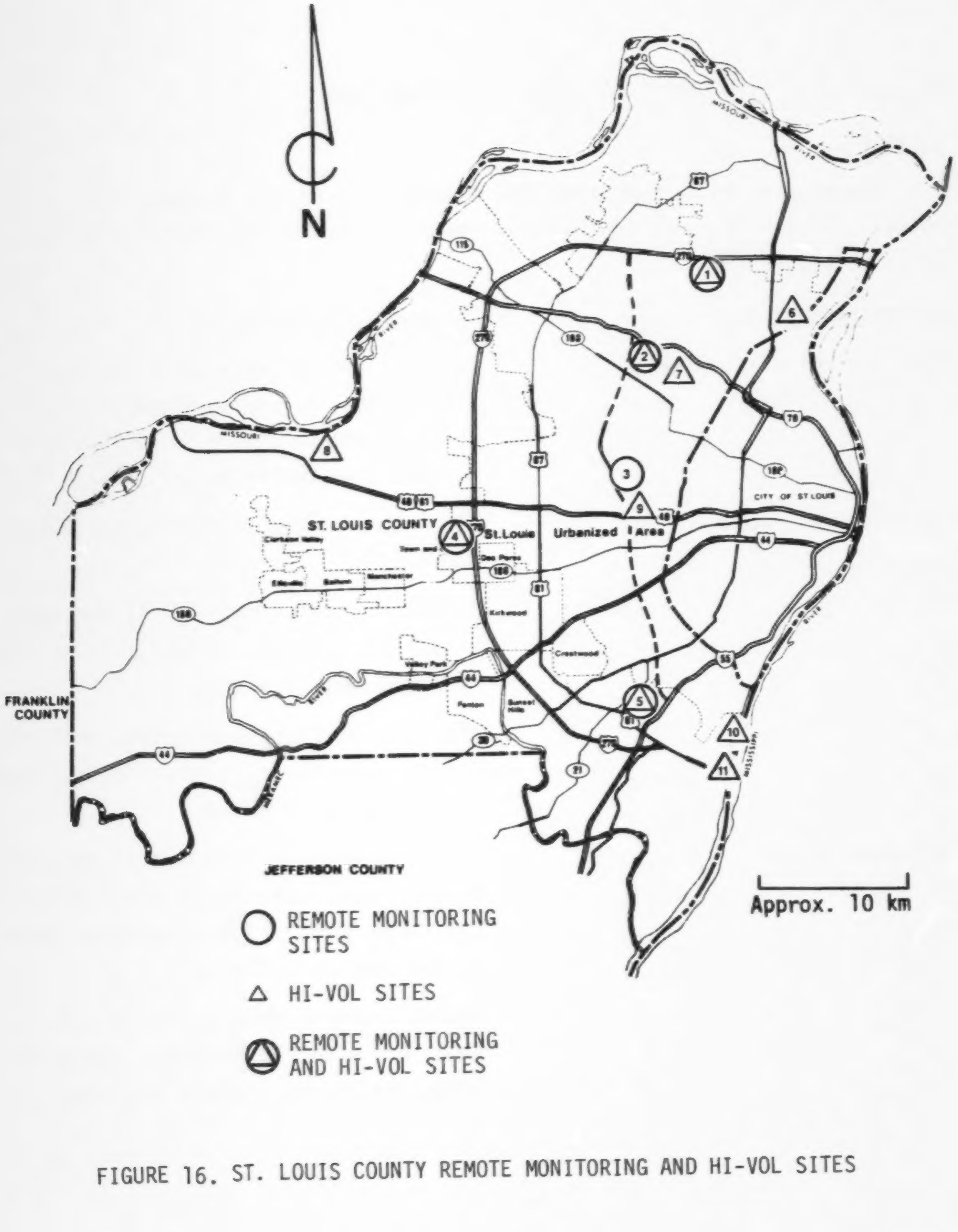

FIGURE 16. ST. LOUIS COUNTY REMOTE MONITORING AND HI-VOL SITES

Parameters Measured	Instrument/Method Used (continued)
Total Hydrocarbons	Pacific 1552 flame ionization total hydrocarbon analyzer, 0 to 20 ppm range. Concentrations read to the nearest 0.10 ppm.
Carbon Monoxide	A MSA Lira Model 500 infrared analyzer, 0 to 50 ppm range. Concentrations read to the nearest 0.10 ppm.
Ozone	Monitor Lab Model 8400 chemiluminescent ozone analyzer, 0 to 0.5 ppm range. Concentrations read to the nearest 0.01 ppm.
	Technicon Model 1 colorimetric analyzer, 0 to 0.5 ppm range. Concentrations read to the nearest 0.01 ppm.
Aerosol Backscatter	MRI 1550B integrating nephelometer measuring scattering coefficient.
Total Suspended Particulates	General Metals hi-vol particulate samplers. Flow rate is recorded when the clean filter is installed, and when the exposed filter is removed. Flow rate during a sampling interval is the average of these readings. The sample receives laboratory analysis for sulfates, nitrates and six trace metals (Pb, Mn, Cu, Fe, Cd, Zn), in addition to mass loading.

Observation Interval

All remote telemetry data are recorded instantaneously every three minutes for each parameter by the on-site acquisition system. This system transmits fifteen minute averages to the central computer complex located at the St. Louis County Air Pollution Board Office. Here the fifteen minute averages are further integrated to hourly averages and archived. Hi-vols sample once every six days from 0000-2400 CST. All hi-vols were operational prior to 1972 except for hi-vol 8, which was activated in 1976. Periods of operation for remote monitoring sites are annotated in Table 18.

Calibration and Quality Control Procedures

Litton Wind System	Except for factory calibration and initial orientation, no calibration is performed on this equipment.
Litton Thermistor	The temperature sensors at different locations within the monitoring system are compared with each other to determine if any discrepant readings are being produced.
Technicon Model I SO_2 Analyzer	Static color and span calibrations are performed once every four months. A Metronics NBS traceable permeation tube and a Dynacal 201-P dilution system are used for the span calibrations.
Meloy SA-125 SO_2 Analyzer	The analyzer is calibrated once every four months utilizing a Metronics NBS traceable permeation tube and a Dynacal 201-P dilution system. The permeation tube temperature is maintained by a controlled temperature oven which is an integral part of the dilution system.
Technicon Model I NO_X Analyzer	Except for periodic cleaning, no calibration is performed on this system.
Thermo Electron NO_X Analyzer	Static color calibration and span calibrations are performed once every two months. A cylinder of Scott NO is used in conjunction with a homemade ozone generator for NO and NO_2 calibrations.

TABLE 18. ST. LOUIS COUNTY REMOTE TELEMETRY STATION EQUIPMENT

STATION	WIND SPEED	WIND DIRECTION	TEMPERATURE	SULFUR DIOXIDE	NITROGEN DIOXIDE	NITROGEN OXIDE	TOTAL HYDROCARBONS	CARBON MONOXIDE	OZONE	BACK SCATTERING
1	Litton Anemometer 1972-1977	Litton Wind Vane 1972-1977	Litton Thermistor 1972-1977	Technicon 1968-1976 Meloy SA-125 1976-1977	Technicon 1968-1977	Technicon 1968-1977	Pacific 1552 1972-1977	MSA Lira 500 1969-1977	Technicon 1968-1974 Monitor Lab 8400 1974-1977	MRI 1550 B Integrating Nephelometer 1972-1977
2	Litton Anemometer 1972-1977	Litton Wind Vane 1972-1977	Litton Thermistor 1972-1977	Technicon 1968-1976 Meloy SA-125 1976-1977	Technicon 1968-1976 Thermo Electron 1976-1977	Technicon 1968-1976 Thermo Electron 1976-1977	Pacific 1552 1972-1977	MSA Lira 500 1969-1977	Technicon 1968-1974 Monitor Lab 8400 1974-1977	MRI 1550 B Integrating Nephelometer 1972-1977
3	Litton Anemometer 1972-1977	Litton Wind Vane 1972-1977	Litton Thermistor 1972-1977	Technicon 1968-1976 Meloy SA-125 1976-1977	Technicon 1968-1977	Technicon 1968-1977	Pacific 1552 1972-1977	MSA Lira 500 1969-1977	Technicon 1968-1974 Monitor Lab 8400 1974-1977	MRI 1550 B Integrating. Nephelometer 1972-1977
4	Litton Anemometer 1972-1977	Litton Wind Vane 1972-1977	Litton Thermistor 1972-1977	Technicon 1968-1976 Meloy SA-125 1976-1977	Technicon 1968-1977	Technicon 1968-1977	Pacific 1552 1972-1977	MSA Lira 500 1969-1977	Technicon 1968-1974 Monitor Lab 8400 1974-1977	MRI 1550 B Integrating Nephelometer 1972-1977
5	Litton Anemometer 1972-1977	Litton Wind Vane 1972-1977	Litton Thermistor 1972-1977	Technicon 1968-1976 Meloy SA-125 1976-1977	Technicon 1968-1977	Technicon 1968-1977	Pacific 1552 1972-1977	MSA Lira 500 1969-1977	Technicon 1968-1974 Monitor Lab 8400 1974-1977	MRI 1550 B Integrating Nephelometer 1972-1977

Calibration and Quality Control Procedures (continued)

	Concentrations of the combined gases were determined by gas phase titration.
Pacific 1552 Total Hydrocarbon Analyzer	A dilute Matheson cylinder source gas is used for calibration once every four months.
MSA Lira Model 500 CO Analyzer	A dilute Scott cylinder of NBS traceable standard gas is used for calibrations once every four months.
Monitor Lab Model 8400 Ozone Analyzer	A homemade ozone generator is utilized for field calibrations once every four months. The ozone generator is calibrated using the Federal Reference (Wet Chemical) Method annually.
Technicon Model I Ozone Analyzer	Static color and span calibrations are performed once every four months. The homemade ozone generator utilized for field calibrations is calibrated using the Federal Reference (Wet Chemical) Method annually.
MRI 1550 B Integrating Nephelometer	Calibration using Freon 12 is performed only when anomalies appear in the aerosol data.
General Metals Particulate Sampler	A calibrated orifice plate and a manometer are used to calibrate the hi-vol flow meter twice a year.

Daily quality control procedures are performed on the data received from the remote telemetry stations. All parameters are visually checked for anomalies. Any apparent discrepancies are rechecked to assure the validity of the data.

Instrument Location

The locations of the remote monitoring and hi-vol sites are represented in Figure 16. Table 18 delineates the equipment located at each remote telemetry station.

Location and Type of Data Available

All data are available on magnetic tape in SAROAD format. These are available through the County Air Pollution Control Board or from the State Division of Environmental Quality in Jefferson City. The data are eventually submitted to the EPA, Region VII office in Kansas City, Missouri who in turn submit them to the NADB at Research Triangle Park. Prior to 1975 most data appear to be of doubtful quality. Subsequent data appear to improve. According to St. Louis County Air Pollution Control Branch personnel, all of the sulfur dioxide, nitrogen oxide and ozone data produced by the Technicon instruments are of dubious quality. Data are available from Ashuin Gajjar (address below).

For data from the National Aerometric Data Bank contact:

Rowena Micheals
Environmental Protection Agency, Region VII
324 East 11th Street
Kansas City, MO 64106

(816) 374-5493

Location of Information Concerning Data Collection

Ashuin Gajjar
St. Louis County Air Pollution Control Branch
801 S. Brentwood Boulevard
Clayton, MO 63105

(314) 726-1100
Ext. 281 or 282

10.3 PRIVATE INDUSTRY

10.3.1 UNION ELECTRIC COMPANY

Location

The Union Electric Company operates thirteen ambient air monitoring sites in the RAPS study area. Twelve of these sites are equipped with High Volume particulate samplers and sulfur dioxide analyzers. The thirteenth site has only the sulfur dioxide analyzer operating. The spatial distribution and respective instrumentation of the sites are represented in Figure 17.

Parameters Measured	Instrument/Method Used
Sulfur Dioxide	Leeds-Northrup Aeroscan Model 7860 conductometric analyzer coupled with a Leeds-Northrup 18091 strip chart recorder, 0 to 1 ppm range. Concentrations read to the nearest 0.01 ppm.
Total Suspended Particulates	Mine Safety Appliance High Volume particulate sampler. The flow rate is assumed to remain constant throughout the hi-vol operating period.

Observation Interval

The hi-vols sample on a six day schedule with an active sampling period 0000 through 2400 CST. The SO_2 analyzers sample continuously and record on strip charts. The observations are manually reduced to half hour averages. The half hour averages are further reduced to hourly summaries on the final processed magnetic tape. All monitoring sites were operational prior to 1972 except for the two sites located near the Rush Island power plant which became operational in 1976.

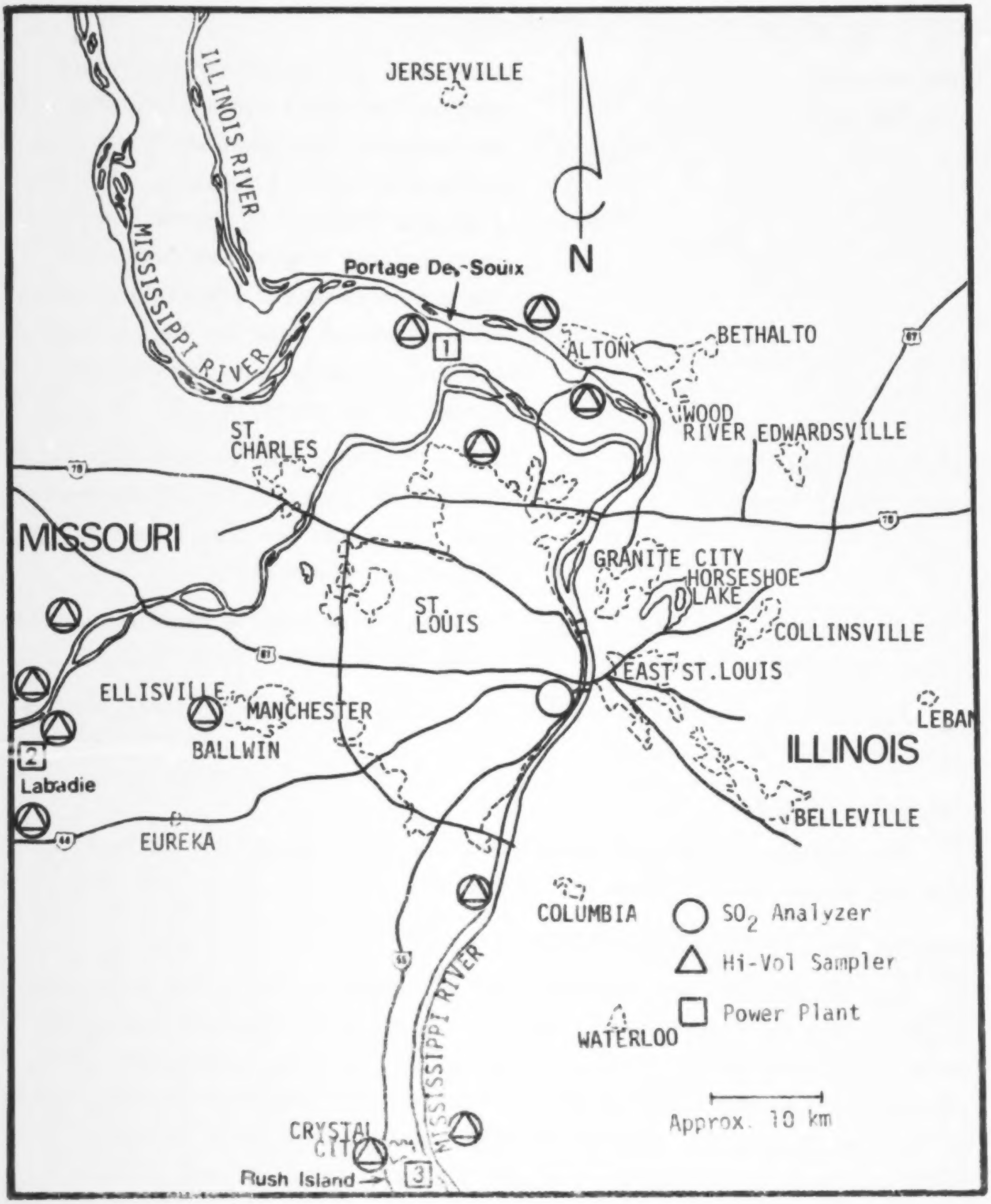

FIGURE 17. UNION ELECTRIC AIR MONITORING SITES

Calibration and Quality Control Procedures

Leeds-Northrup SO_2 Analyzer	Once every six months the instrument is removed from the field and replaced with an identical instrument which has been calibrated in the laboratory. An NBS traceable Metronix SO_2 permeation tube in a constant temperature oven and a Combustion Equipment Association dilution system are used for the calibration process. A daily zero check is performed in the field.
Mine Safety Appliance Particulate Samplers	The particulate samplers are calibrated every four months in the laboratory by determining the air flow using orifice plates and a manometer.

The sampling sites are serviced twice weekly by a field technician. The reagent utilized by the SO_2 analyzer is renewed weekly.

All data receives stringent quality control checks in the field and during the reduction process.

Instrument Location

The location of the monitoring sites and their respective instrumentation are delineated in Figure 17.

Location and Type of Data Available

Data are available as 9 track, 1600 bpi magnetic tape. The data coding is EBCDIC and the file format is tailored to fit Union Electric's specific needs. Processed data are available as hourly averages. Unprocessed data are available on magnetic tape at half hour averages and also on strip chart at the same frequency. Computer printouts are also available as hourly averages. For information on data availability contact Michael L. Menne (address on following page).

Location of Information Concerning Data Collection

Michael L. Menne
Union Electric Company
Environmental Services Department
P. O. Box 149
1901 Gratiot Street
St. Louis, MO 63166

(314) 621-3222

10.3.2 ILLINOIS POWER COMPANY

Location

The Illinois Power Company operates six air monitoring sites within the RAPS study area. Three units are associated with the Illinois Power generating facility at Wood River and three are situated in the vicinity of the Baldwin power plant. One unit at each location is equipped with a recording wind system. The location and respective instrumentation of each site is designated in Figure 18.

Parameters Measured	Instrument/Method Used
Sulfur Dioxide	Technicon Air Monitor II A colorimetric SO_2 analyzer, 0 to 1 ppm range. Concentrations read to the nearest 0.01 ppm. Meloy SA-185-2 and SA-160-2 flame photometric SO_2 analyzer, 0 to 1 ppm range. Concentrations read to the nearest 0.01 ppm.
Total Suspended Particulates	Environmental Measurement 500 particulate samplers. Flow rate is recorded when the clean filter is installed, and when the exposed filter is removed. Flow rate during a sampling interval is the average of these readings.
Wind Speed and Direction	A Belfort aerovane wind system expressing direction in degrees of azimuth with respect to true north and wind speed in miles per hour.

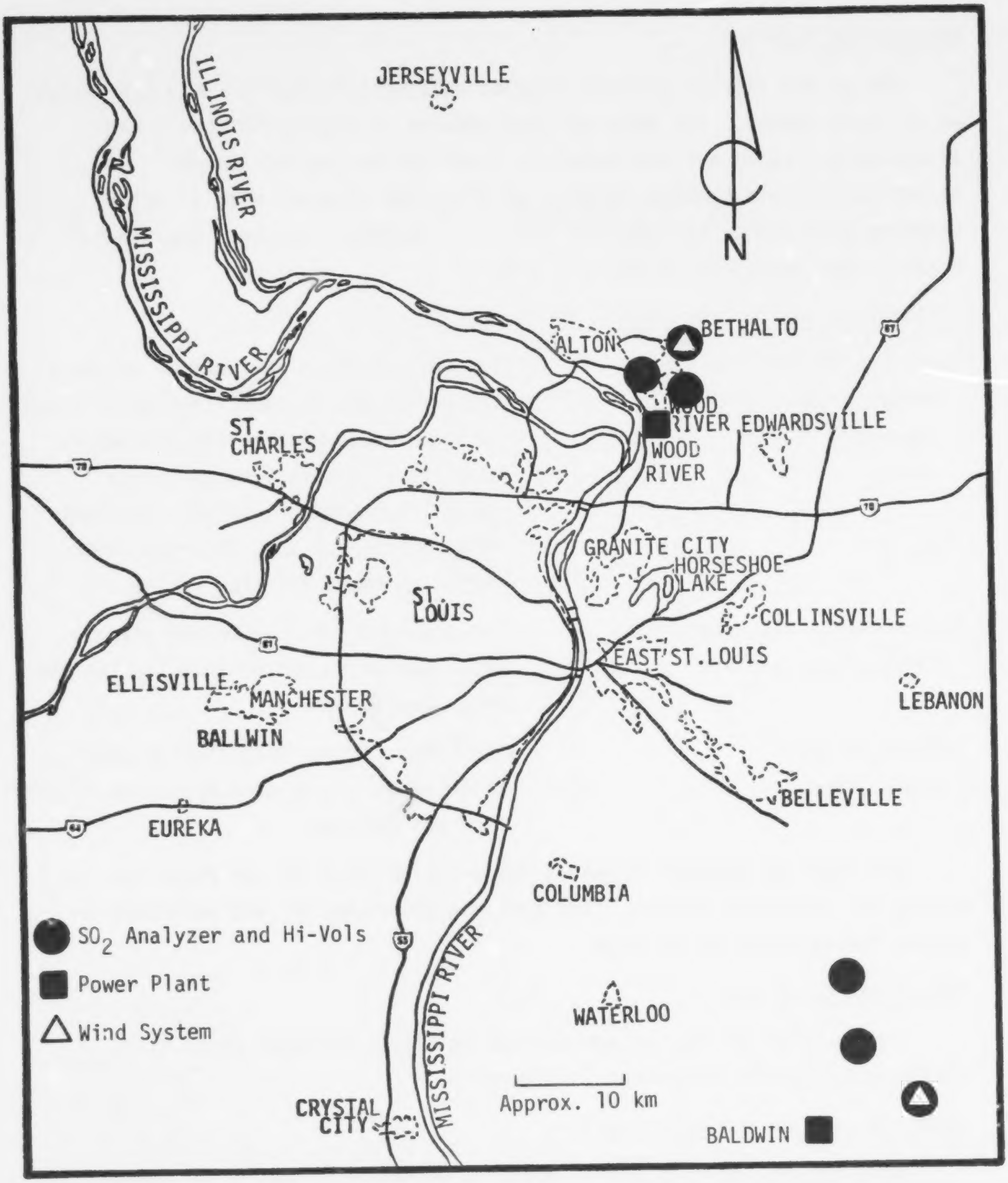

FIGURE 18. ILLINOIS POWER AIR MONITORING SITES

Observation Interval

The sulfur dioxide analyzer samples continuously and its data are recorded on strip charts. The data are then reduced to hourly averages. Wind direction and speed are monitored and expressed in the same manner. The hi-vol particulate samplers monitor on a six day interval with an active sampling period 0000 through 2400 CST. All equipment has been operational prior to the inception of the RAPS program.

Calibration and Quality Control Procedures

Technicon Air Monitor II A, Meloy SA-185-2 and SA-160-2 Analyzers	The instrument is replaced on an annual basis with an identical instrument which has been calibrated in the laboratory. Laboratory calibrations utilize a Dynacal permeation tube in a constant temperature bath used in conjunction with a homemade dilution system.
Environmental Measurement Particulate Samplers	The instrument is calibrated using a water manometer during installation and motor replacement.
Belfort Aerovane Wind System	Since the initial installation and orientation of the wind system no calibration has occured.

All data are visually examined for anomalies both in the field and during the reduction process. Any apparent discrepancies are rechecked to assure the validity of the data.

Instrument Locations

The location of the various monitoring sites and their respective instrumentation are delineated in Figure 18.

Location and Type of Data Available

Data are available as hourly averages on magnetic tape or as computer printout. Data are available from Jim May (address on following page).

Location of Information Concerning Data Collection

Jim May
Illinois Power Company
500 South 27th Street
Decatur, IL 62525

(618) 424-6835

11.0 LOCAL METEOROLOGICAL MONITORING NETWORKS

Introduction

Included in Section 11.0 are descriptions of local meteorological monitoring networks operated in the RAPS study area by the federal government and the Air Force, by educational institutions, and by private industry. Except for instruments mounted on towers, all of these measurements are considered surface observations; meteorological measurements obtained aloft are described in Section 4.0.

The purpose for documenting these local monitoring networks is to provide supplementary sources of meteorological information for RAPS researchers. In addition, these networks are more suitable for studying climatological trends in the St. Louis area than the short-term RAMS network.

11.1 NATIONAL WEATHER SERVICE

11.1.1 FIRST ORDER STATIONS

11.1.1.1 LAMBERT - ST. LOUIS INTERNATIONAL AIRPORT

Location

Northwestern corner of the St. Louis Metropolitan Area (Figure 19, Map Location A).

Parameters Measured	Instrument/Method Used
Cloud Height	A Crouse-Hinds rotating beam ceilometer supplemented by a Westinghouse ceiling light. Additional information is obtained from pilot estimations. All observations are recorded in feet above ground level.
Surface Visibility	Visually determined according to National Weather Service standards and expressed in miles.
Runway Visibility	Two Solid State Devices FAA Model 7872 transmissometers using 250 foot and 500 foot baselines supplemented by pilot estimations and recorded in feet.
Altimeter Setting and Barometric Pressure	One Kollsman altimeter, a Julian P. Friez one day recording barograph and a H. J. Green mercurial barometer all indicating in inches of mercury.
Ambient Air Temperature	Weston averaging resistance thermistor with single element remote reading, measuring in degrees Fahrenheit.

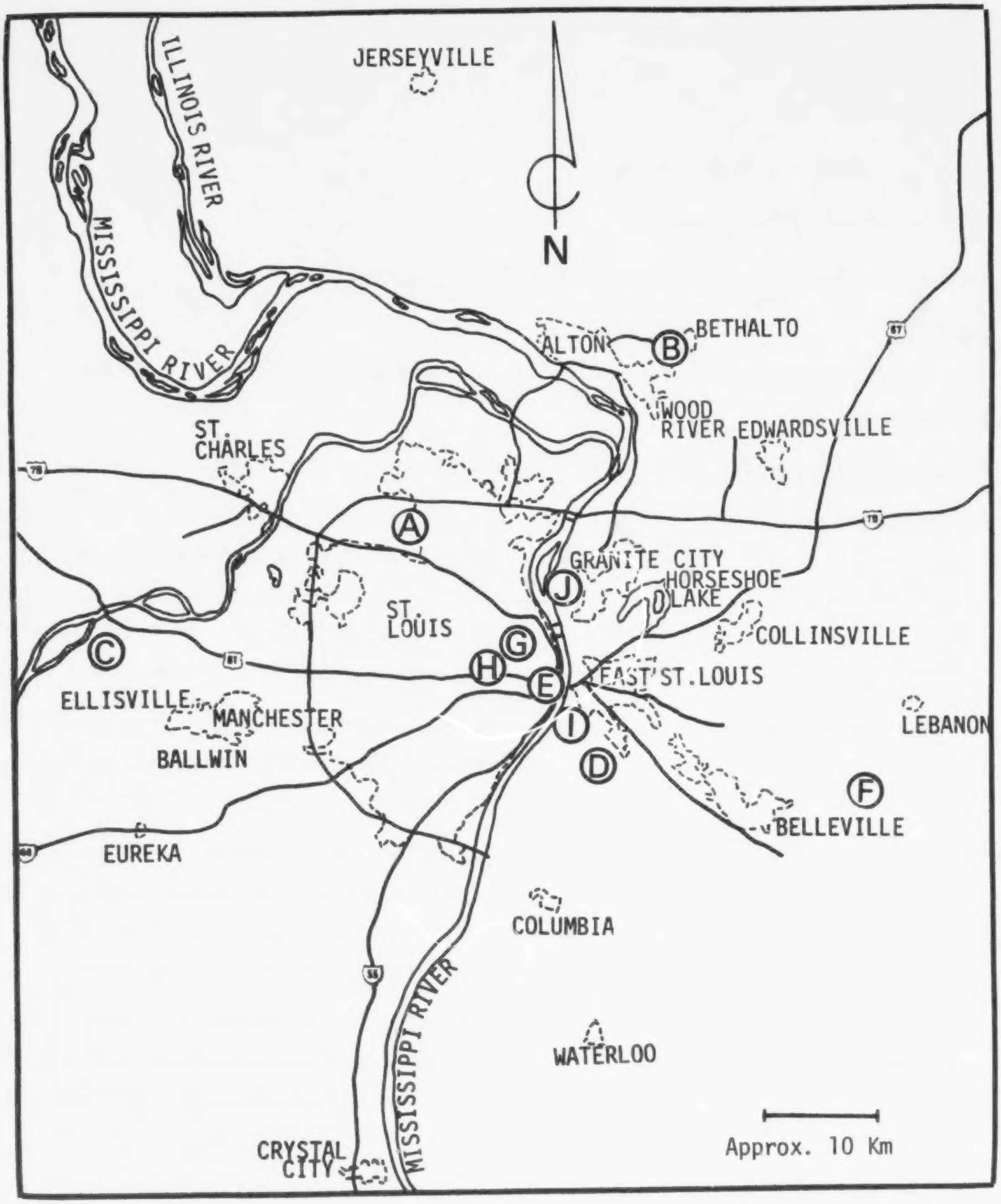

FIGURE 19. LOCATIONS OF LOCAL METEOROLOGICAL DATA COLLECTION SITES

Parameters Measured	Instrument/Method Used (continued)
Dew Point	National Weather Service remote reading dew point cell measuring in degrees Fahrenheit.
Relative Humidity	Derived with a psychrometric calculator using readings from dew point and temperature sensors and recorded as a percentage.
Total Opaque Sky	Visually determined according to National Weather Service standards and expressed as a percentage.
Precipitation	A Belfort Universal weighing rain gauge recording on a rotating drum supplemented by an eight inch diameter Friez stick and cylinder rain gauge, as well as a Friez tipping bucket rain gauge that records both digitally and on a rotating drum. All the above units record to hundredths of an inch.
Ambient Radiation	Victoreen Geiger counter measuring milliroentgens per hour.
Wind Speed and Direction	Electra Speed F-420 wind system using a three cup anemometer and directional vane. Speed is displayed in knots and direction as degrees azimuth with reference to true north.
Minutes of Sunshine	A National Weather Service designed photoelectric switch coupled to an Esterline Angus Multiple Recorder, measuring the total minutes of sunshine.

Observation Interval

Ambient radiation measurements are taken weekly. All other observations are performed seven days a week at hourly intervals. Special observations are initiated when the ceiling height descends below three thousand feet, one thousand feet and at each decreasing one hundred foot interval down to the surface. These observations are also taken when surface visibility is reduced to three miles, two miles and at decreasing quarter mile intervals thereafter until zero visibility is reached. Special observations are also taken when the process reverses and the visibility and ceiling height increase through their respective increments. The beginning, ending, or changes in intensity of precipitation, severe meteorological phenomena or significant changes in wind speed and direction also call for special observations. Observations were continuous throughout the duration of the RAPS program.

Calibration and Quality Control Procedures

Rotating Beam Ceilometer	The rotating beam ceilometer is mechanically aligned once every two weeks. Total alignment is done biannually.
Ceiling Light	The ceiling light is checked four times a year to assure perfect vertical orientation.
Altimeter	The altimeter is compared weekly to the H. J. Green mercurial barometer. The altimeter is always adjusted to agree with the mercurial barometer.
Recording Barograph	The barograph is compared to the Kollsman altimeter every six hours. The two readings must fall within ± 0.05 inches of mercury.
Mercury Barometer	The mercury barometer is calibrated yearly with two portable precision aneroid barometers used by the National Weather Service as a barometric standard.

Calibration and Quality Control Procedures. (continued)

Transmissometers	The transmissometers are visually and mechanically aligned every two weeks. Complete calibration and comparison to visual standards are performed biannually.
Temperature Sensor	The thermistor is compared weekly to a National Weather Service #391316 mercury thermometer. The comparison must fall within ± 2.0° Fahrenheit. The thermistor is either recalibrated or replaced if a discrepancy larger than the allowable limit exists.
Dew Point Sensor	The dew point is compared weekly to the dew point derived by using a sling psychrometer with National Weather Service #391316 mercury thermometers and a psychrometric calculator. The indicated dew point must be within ± 2.0° Fahrenheit of the calculated dew point.
Rain Gauges	With the exception of periodic cleaning and drainage, no calibration is performed.
Anemometer and Direction Vane	The anemometer is checked weekly. Total calibration using a constant RPM motor is done annually if not required sooner. The directional indicator is checked weekly using an electronic test box. Directional orientation is to true north utilizing solar noon for alignment.

Quality control of the observations is performed daily by a designated observer, then re-examined by the station supervisor before being submitted to the National Climatic Center.

Instrument Location

Rotating Beam Ceilometer	Near Frost Avenue on northeast end of runway complex.
Ceiling Light	Center of runway complex.
Transmissometers	Located at approach ends of runways twelve and twenty-four.
Temperature and Dew Point Sensors	Middle of runway complex.
Anemometer and Directional Vane	Middle of runway complex.
Barometer, Barograph and Altimeter	National Weather Service Office in old terminal building at west end of field.
Rain Gauges	National Weather Service Office in old terminal building at west end of field.
Sunshine Meter	National Weather Service Office at old terminal building at west end of field.

Location and Type of Data Available

Data can be obtained from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683 Summaries and Micro-fiche
Ext. 203 Magnetic Tapes

Hourly data are available on micro-fiche or as copies of the MF1-10A and MF1-10B hourly summaries. The hourly data for 1975, 1976 and January through May of 1977 have been obtained on magnetic tape by the Data Management Branch at Research Triangle Park. Data for three hour intervals can be obtained on micro-fiche, magnetic tape and in copies of the Local Climatological Data Book.

Location of Information Concerning Data Collection

National Weather Service
4100 Mexico Road
St. Peters, MO 63376

(314) 946-7610

11.1.2 SECOND ORDER STATIONS

11.1.2.1 ALTON CIVIC MEMORIAL AIRPORT

Location

In Alton, Illinois, northeast of the St. Louis Metropolitan Area (Figure 19, Map Location B).

Parameters Measured	Instrument Method Used
Cloud Height	Crouse-Hinds rotating beam ceilometer supplemented by pilot observations. Cloud heights are measured in feet above ground level.
Surface Visibility	Visually determined according to National Weather Service standards and reported in miles.
Altimeter Setting	Two Kollsman altimeters indicating in inches of mercury.
Wind Direction and Speed	Electra Speed F-420 wind system using a three cup anemometer. Speed is indicated in knots and direction in degrees azimuth with reference to true north.

Observation Interval

Observations are taken hourly, seven days a week from 0500 CST to 2100 CST. Special observations are initiated when the ceiling height descends below three thousand, one thousand and at each decreasing one hundred foot interval down to the surface. These observations are also taken when surface visibility is reduced to three miles, two miles and at decreasing quarter mile intervals thereafter until zero visibility is reached. Special observations are also taken when the process reverses and the visibility and ceiling height increase through their respective increments. The beginning, the end, or changes in intensity of precipitation, severe meteorological phenomena, or significant changes in wind direction and speed also call for special observations. Observations were made throughout the RAPS program.

Calibration and Quality Control Procedures

Rotating Beam Ceilometer	Electrical tests are made weekly and more extensive electronic tests are performed each quarter. Leveling and mechanical adjustments are performed on an annual basis.
Altimeters	The two altimeters are compared daily. Readings must fall within ± 0.02 inches of mercury. If the range proves to be greater than ± 0.02 inches of mercury, the National Weather Service at Lambert Field is contacted to determine the correct setting from the mercurial barometer. The National Weather Service calibrates the Kollsman altimeters annually with two precision aneroid barometers from Kansas City.
Anemometer and Directional Vane	The Electra Speed F-420 wind system is calibrated every six months. Speed is calibrated using a constant RPM motor. Directional orientation is to true north utilizing solar noon for alignment.

Instrument Location

The rotating beam ceilometer parallels runway 29. All other monitoring devices are located at the control tower.

Location and Type of Data Available

Data are available as copies of the hourly summary form MF1-10C. Microfiche copies are available for the years 1973, 1974 and 1975.

Data may be obtained from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683

Location of Information Concerning Data Collection

Alton Air Traffic Control Tower
P. O. Box 66
Cottage Hill, IL 62018

(618) 259-2531

11.1.2.2 SPIRIT OF ST. LOUIS AIRPORT

Location

Adjacent to the Missouri River in the west central section of the St. Louis Metropolitan area (Figure 19, Map Location C).

Parameters Measured	Instrument/Method Used
Cloud Height	A Crouse-Hinds ceiling light is supplemented by ceiling balloon observations when needed. Pilot observations are used in conjunction with the other methods. All estimates are recorded in feet above ground level.
Surface Visibility	Visually determined according to National Weather Service standards and expressed in miles.
Altimeter Setting	One Kollsman altimeter recording in inches of mercury.
Wind Direction and Speed	An Electra Speed F-420 wind system using a three cup anemometer, indicating speed in knots and direction in degrees azimuth with reference to true north.

Observation Interval

Prior to May 1976, observations were made hourly when the control tower was operational. Due to the varying periods of operation, exact observation hours should be obtained from the National Climatic Center. Since May 1976 observations are made hourly, twenty-four hours a day. Special observations are initiated when the cloud height falls below three thousand feet, one thousand feet and at each decreasing one hundred foot interval down to the surface. These observations are also taken when surface visibility is reduced to three miles, two miles and at decreasing quarter mile intervals thereafter until zero visibility is reached. Special observations are also made when the process reverses and the visibility and ceiling height increase through their respective increments. The beginning, the end, or changes in intensity of precipitation, severe meteorological phenomena, or significant changes in wind direction and speed also call for special observations. Observations were made throughout the RAPS program.

Calibration and Quality Control Procedures

Ceiling Light	The ceiling light was aligned vertically and locked into position when it was installed in 1969. This is the only maintenance performed aside from periodic cleaning and lamp replacement.
Altimeter	The Kollsman altimeter is compared daily to the setting issued by the National Weather Service at Lambert Field. The altimeter is calibrated yearly with two precision aneroid barometers provided by the Kansas City National Weather Service office.
Anemometer and Directional Vane	The Electra Speed F-420 wind system is calibrated once every six months by National Weather Service personnel. Speed is calibrated by using a constant RPM motor. Directional orientation is to true north utilizing solar noon for alignment.

All data are reviewed prior to submittal to the National Climatic Center.

Instrument Location

The ceiling light is located in the runway complex. All other monitoring devices have been located in the flight service center since May 1976, when they were moved from the control tower.

Location and Type of Data Available

Data are available as copies of the MF1-10C summary sheets. For the years 1973 and 1974 micro-fiche are available. These can be acquired from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683

Location of Information Concerning Data Collection

Spirit of St. Louis Airport
Flight Service Center
57 Edison
Chesterfield MO 63017

(314) 532-1011

11.1.2.3 PARKS BI-STATE AIRPORT

Location

In Cahokia, Illinois, east of the St. Louis Metropolitan Area (Figure 19, Map Location D).

Parameters Measured	Instrument/Method Used
Cloud Height	Since November 1976 a Crouse-Hinds ceiling light has been used supplemented by ceiling balloons. Prior to this date, visual estimation, pilot estimation and ceiling balloons were used. Cloud height is recorded in feet above ground level.
Surface Visibility	Visually determined according to National Weather Service standards and expressed in miles.
Altimeter Setting	Aero Mechanism altimeter indicating in inches of mercury.
Wind Direction and Speed	Electra speed F-420 wind system using a three cup anemometer, indicating speed in knots and direction in degrees azimuth with reference to true north.

Observation Interval

From December 1973 to December 1974 observations were made hourly from 0800 CST to 2000 CST. When on daylight savings time the hours were 0700 CST to 1900 CST. Since December 1974 observations were made between 0700 CST and 2100 CST, and when on daylight savings time between 0600 CST and 2000 CST. Special observations are initiated when the ceiling height descends below three thousand feet, one thousand feet and at each decreasing one hundred foot interval down to the surface. These observations are also made when the surface visibility is reduced to three miles, two miles, and at decreasing quarter mile intervals thereafter until zero visibility is reached. Special observations are also taken when the process reverses and the visibility and ceiling height increase through their respective increments. The beginning, the end, or changes in intensity of precipitation, severe meteorological phenomena, or significant changes in wind direction and speed also call for special observations. Observations have been made prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

Ceiling Light	The ceiling light is checked monthly for vertical alignment and proper functioning of the lighting unit.
Altimeter	The altimeter is compared daily to the National Weather Service setting from Lambert Field. The National Weather Service calibrates the altimeter annually using two precision aneriod barometers from the Kansas City office.
Anemometer and Directional Vane	The Electra Speed F-420 wind unit is calibrated every six months. Speed is calibrated with a constant RPM motor. Directional orientation is to true north utilizing solar noon for alignment.

Instrument Location

The ceiling light is located in the runway complex and the other instruments are situated at the control tower.

Location and Type of Data Available

Data are available as copies of the summary from MF1-10C. These may be acquired from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683

Location of Information Concerning Data Collection

Parks Bi-State Airport
1400 Upper Cahokia Road
Cahokia, IL 62206

(618) 337-5660

11.1.3 COOPERATIVE WEATHER OBSERVERS

11.1.3.1 GATEWAY ARCH INSTRUMENT SHELTER

Location

Downtown St. Louis, Missouri in Jefferson National Expansion Memorial Park (Figure 19, Map Location E).

Parameters Measured	Instrument/Method Used
Daily Maximum-Minimum Temperature	Weksler recording maximum-minimum thermometer indicating degrees Fahrenheit.
Total Daily Precipitation	Fisher-Porter weighing rain gauge recording to the nearest hundredth of an inch.

Observation Interval

Observations are made once a day, seven days a week. Data have been collected since 1967.

Calibration and Quality Control Procedures

The equipment is calibrated annually by a National Weather Service crew from Kansas City. No quality control of the data is performed on site. Routine review of the data occurs at the National Climatic Center.

Instrument Location

The equipment is located on the Jefferson National Expansion Memorial Park grounds.

Location and Type of Data Available

Data are available in the Missouri Climatological Data Book and on micro-fiche for the years 1967 through 1976. These data can be acquired from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683

Location of Information Concerning Data Collection

National Weather Service
4100 Mexico Road
St. Peters, MO 63376

(314) 946-7610

11.2 AIR WEATHER SERVICE

11.2.1 SCOTT AIR FORCE BASE

Location

Located east of Belleville, Illinois, southeast of the St. Louis Metropolitan Area (Figure 19, Map Location F).

Parameters Measured	Instrument/Method Used
Cloud Height	Two Air Weather Service GMQ-13 rotating beam ceilometers. These are occasionally supplemented by pilot estimates and are measured in feet above ground level.
Surface Visibility	Visually determined according to Air Weather Service standards and expressed in miles.
Runway Visibility	Two Air Weather Service GMQ-10 transmissometers with five hundred foot baselines. Visibility is expressed in feet.
Altimeter Setting and Barometric Pressure	One Air Weather Service ML-102 aneroid altimeter, a ML-563 four day recording barograph and a ML-512 mercury barometer. All instruments indicate inches of mercury.
Ambient Air Temperature	TMQ-11 electrical resistance thermistor with remote dial readout in degrees Fahrenheit.
Dew Point	TMQ-11 remote reading dew point cell measuring in degrees Fahrenheit.

Parameters Measured	Instrument/Method Used (continued)
Total Opaque Sky	Visually determined according to the Air Weather Service standard and expressed as a percentage.
Precipitation	A ML-17 stick and cylinder rain gauge recording to the nearest hundredth of an inch.
Wind Speed and Direction	A 3AN/GMQ-20 transmitter combined with a RO-362 wind speed and direction recorder. Speed is recorded in knots and direction in degrees with reference to magnetic north.

Observation Interval

All observations are made at hourly intervals seven days a week. Special observations are initiated when the ceiling height descends below three thousand feet, one thousand feet, eight hundred feet and at decreasing one hundred foot intervals until three hundred feet is reached. These observations are also made when visibility is reduced to six thousand feet, four thousand feet, two thousand, and four hundred feet. Observations are also made when the process reverses and the visibility and ceiling height increase through their respective increments. The beginning, the end, or changes in intensity of precipitation, severe meteorological phenomena, or significant changes in wind direction and speed also call for special observations. Observations have been made prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

Rotating Beam Ceilometers	The transmitter and receiver of the rotating beam ceilometers are checked as needed. An extensive check of the rotary mount, alignment, power output, and photo cell is made every twenty-eight days.

Calibration and Quality Control Procedures (continued)

Transmissometers	A check is made every twenty-eight days to assure proper alignment and electrical operation.
Altimeter	The altimeter is compared weekly to the ML-512 mercury barometer. The altimeter is always adjusted to agree with the mercury barometer.
Recording Barograph	No calibration is performed since only pressure tendencies are monitored.
Mercury Barometer	Calibrated yearly with two precision aneroid barometers supplied by the Air Weather Service from Wright-Patterson Air Force Base.
Rain Gauge	No calibration is performed on the stick and cylinder rain gauge.
Temperature and Dew Point Sensors	The TMQ-11 electrical resistance thermistor and the dew point cell are compared weekly to the ML-24 sling psychrometer and a ML-429 psychrometric calculator. The indicated temperature and dew point must fall within 1.0 and 1.5 degrees Fahrenheit, respectively of the readings produced by the sling psychrometer and the psychrometric calculator.
Anemometer and Directional Vane	The transmitter is calibrated weekly for both speed and direction. The speed is calibrated by using a constant RPM motor. The directional unit is tested electronically for consistency. The RO-362 recorder is also checked to assure that it is operating at the correct recording speed.

Data receive daily examination by a designated observer. The station supervisor reviews all observations before submission to the National Climatic Center.

Instrument Location

The location of the rotating beam ceilometers, transmissometers, temperature and dew point sensors and the anemometers are shown in Figure 20. All other instrumentation is located at the Air Weather Service building.

Location and Type of Data Available

Data can be obtained from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683 Summaries and micro-fiche
Ext. 203 Magnetic tape

Hourly data are available on micro-fiche or as copies of Air Weather Service Form 10. Hourly data can be acquired on magnetic tape by special arrangement. Data for three hour intervals can be obtained on micro-fiche, magnetic tape, and in copies of the Local Climatological Data Book.

Location of Information Concerning Data Collection

Scott Air Force Base
Detachment 9, 7th Weather Wing
Scott Air Force Base, IL 62225

(618) 256-4149

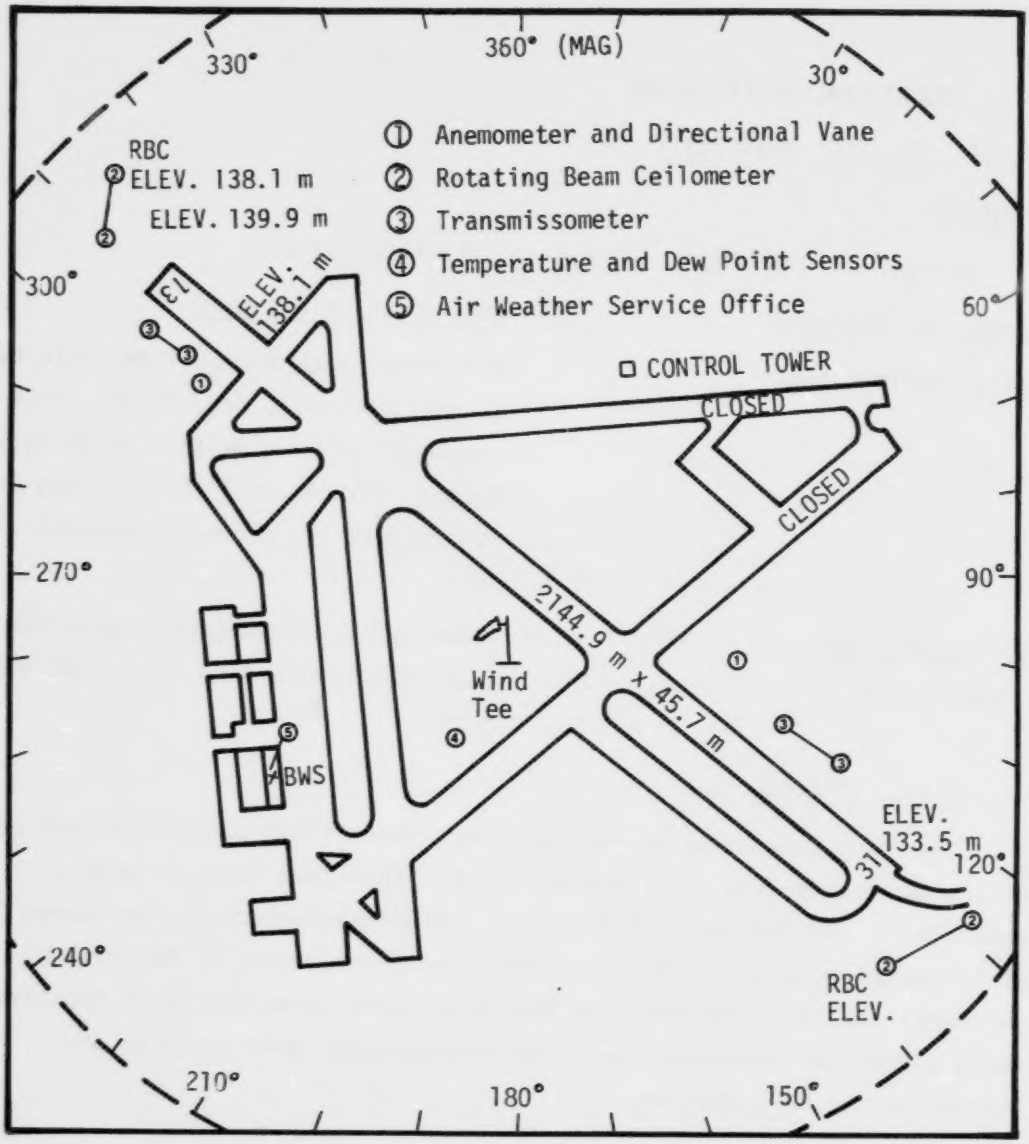

FIGURE 20. SCOTT AIR FORCE BASE INSTRUMENT LOCATIONS

11.3 EDUCATIONAL INSTITUTIONS

11.3.1 ST. LOUIS UNIVERSITY

Location

Central St. Louis City (Figure 19, Map Location G).

Parameters Measured	Instrument/Method Used
Daily Precipitation	A Belfort stick and cylinder rain gauge is used for daily recordings. This is supplemented by a Belfort weighing rain gauge. All rainfall observations are recorded to the nearest hundredth of an inch.
Maximum-Minimum Temperature	A Weksler maximum-minimum recording thermometer recording in degrees Fahrenheit.

Observation Interval

The daily precipitation and daily maximum-minimum temperature are the only measurements made on a regular basis. These are taken as near as possible to 1700 CST seven days a week. Other parameters are monitored but at irregular intervals. St. Louis University Department of Meteorology personnel should be contacted to determine which parameters were monitored for a particular time interval. Observations were made prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

No calibration is performed on the instruments. The data are reviewed prior to submittal to the National Climatic Center.

Instrument Location

The rain gauge and the maximum-minimum thermometer are located on the roof of the Macelwane Building approximately nine meters above ground level. The Macelwane Building is situated on the St. Louis University main campus.

Location and Type of Data Available

Data are available from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683

Data are on micro-fiche and also recorded in the Missouri Climatological Data Book for the years 1896 through 1976.

Location of Information Concerning Data Collection

Donald Martin
St. Louis University
Department of Meteorology
3507 Laclede
St. Louis, MO 63108

(314) 535-3300
Ext. 544

11.4 PRIVATE INDUSTRY

11.4.1 LACLEDE GAS COMPANY

Location

Central St. Louis City (Figure 19, Map Location H).

Parameters Measured	Instrument/Method Used
Wind Speed and Direction	Recording anemometer indicating wind in mph and direction in degrees azimuth with reference to true north.
Ambient Air Temperature	Foxbourough recording thermometer supplemented by a digital thermometer expressing temperature in degrees Fahrenheit.
Net Incoming Solar Radiation	Pyrheliometer recording gram calories/minute/centimeter^2.
Soil Temperature	Thermistors implanted at depths of 22.86 and 45.72 cm, measuring temperature in degrees Fahrenheit.

Observation Interval

All parameters are monitored on a continuous basis and summarized hourly. Observations were made prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

The pyrheliometer is checked annually while the other instrumentation is continuously compared to the National Weather Service measurements. Any measurements exceeding the established margin of error are rechecked.

Instrument Location

All instrumentation with the exception of the soil probes are located on the roof of the Laclede Gas building at the intersection of Vandeventer Avenue and Forest Park Boulevard. The soil probes are located on the north side of the building in a grassy area approximately 30 centimeters from the building.

Location and Type of Data Available

Data are available in strip chart form from Richard Ryan (address below). Data must be cleared with Laclede Gas Administrators before release.

Location of Information Concerning Data Collection

Richard Ryan
Laclede Gas Company
3950 Forest Park
St. Louis, MO 63108

(314) 658-5480

11.4.2 MONSANTO CHEMICAL COMPANY

Location

East of St. Louis in Sauget, Illinois (Figure 19, Map Location I).

Parameters Measured	Instrument/Method Used
Wind Speed and Direction	Currently recorded on Bendix system. Originally recorded on Weathermaker anemometer. Both systems record speed in mph and direction as quadrants with reference to magnetic north.

Observation Interval

All parameters are monitored continuously. Wind shifts were noted on summary sheets when the Weathermaker system was operational, but were discontinued with the installation of the Bendix system. Observations were made prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

No quality control or calibration is performed aside from routine maintenance.

Instrument Location

The anemometer and directional vane are mounted on the plant roof approximately eight meters above ground level.

Location and Type of Data Available

Data are available on recording drums for the Weathermaker instrument and on strip charts for the Bendix system. Summaries of wind shifts may also be available for earlier dates. Data may be obtained from Clarence Buckley (address on following page).

Location of Information Concerning Data Collection

Clarence Buckley
Monsanto Chemical Company
Sauget, IL 62201

(618) 271-5835

11.4.3 UNION ELECTRIC COMPANY

Location

The four monitoring sites are located at the Union Electric power plants in the St. Louis area (Figure 21).

Parameters Measured	Instrument/Method Used
Wind Direction and Speed	A Friez Aerovane Model 120 three propeller anemometer and directional unit is used indicating speed in mph and direction in degrees azimuth with reference to magnetic north.
Ambient Air Temperature	A Leeds-Northrup thermocouple measuring ambient air temperature in degrees Fahrenheit and recording on a strip chart.

Observation Interval

All parameters are monitored continuously. The data are recorded on strip chart and then reduced and logged on magnetic tape. Observations were made prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

Aerovane Model 120 Anemometer	The anemometer is calibrated biannually. The speed is calibrated by using a constant RPM motor. The directional unit is aligned using magnetic north as the orientation point. The unit is visually checked twice weekly to assure normal operation.

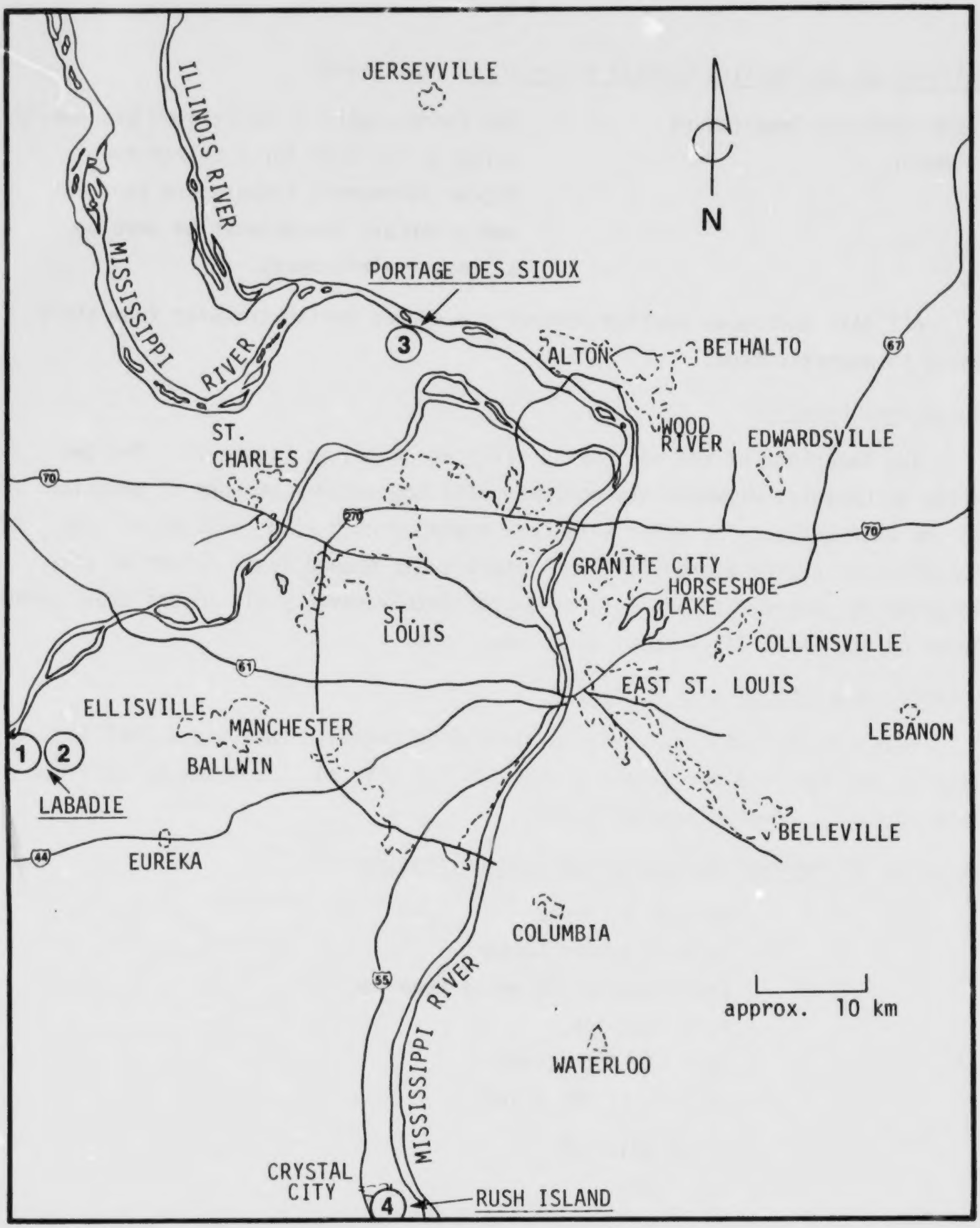

FIGURE 21. UNION ELECTRIC METEOROLOGICAL MONITORING SITES

Calibration and Quality Control Procedures (continued)

Leeds-Northrup Temperature Sensor	The thermocouple is calibrated biannually, using an ice bath for a thirty-two degree Fahrenheit temperature constant and a mercury thermometer to develop a linear relationship.

All data undergoes quality control procedures during transfer from strip chart to magnetic tape.

Instrument Location

The locations of the monitoring sites are shown in Figure 21. The two sites at Labadie, Missouri are equipped with temperature sensors in addition to the wind units. The other sites are equipped with wind units only. The sensors are located approximately 3 meters above ground level except at site location #2 where they are located approximately seventy-six meters above ground level on the Shell Oil Company micro wave tower.

Location and Type of Data Available

Data are available as strip charts and on magnetic tape since 1969 for site #1 and #2, 1968 for site #3, and 1974 for site #4. Data may be obtained from Michael L. Menne (address below).

Location of Information Concerning Data Collection

Michael L. Menne
Union Electric Company
Environmental Sciences Department
P. O. Box 149
1901 Gratiot Street
St. Louis, MO 63166

(314) 621-3222
Ext. 2816

11.5 OTHER AGENCIES

11.5.1 UNITED STATES ARMY CORPS OF ENGINEERS

Location

East of St. Louis Metropolitan Area at Mississippi River Lock No. 27 on the Chain of Rocks Canal (Figure 19, Map Location J).

Parameters Measured	Instrument/Method Used
Weekly Precipitation	Friez stick and cylinder rain gauge measuring to the nearest hundredth of an inch.

Observation Interval

Observations have been made once a week since 1953.

Calibration and Quality Control

All data are reviewed for accuracy.

Instrument Location

The rain gauge is situated in a grassy area adjacent to the Lock Master's building.

Location and Type of Data Available

Data are available on summary sheets. Contact Floyd Wade for information (address below).

Location of Information Concerning Data Collection

Floyd Wade
United States Army Corps of Engineers
Lock No. 27
P. O. Box 1227
Granite City, IL 62040

(618) 452-7107

11.5.2 UNITED STATES GEOLOGICAL SURVEY

Location

The 32 sampling sites are distributed along the various watersheds within St. Louis City and County (Figure 22).

Parameters Measured	Instrument/Method Used
Total Precipitation and Intensity of Precipitation	Fisher-Porter volumetric tipping rain gauge measuring to the nearest hundredth of an inch. The instrument samples every five minutes and records on paper tape. The rain gauges have been modified to United States Geological Survey specifications.
River Stage	Fisher-Porter stage monitor recording to the nearest hundredth of a foot.

Observation Interval

Observations are made every five minutes, twenty-four hours a day, seven days a week. Observations have been continuous since 1972.

Calibration and Quality Control Procedures

All equipment is checked monthly and calibrated as required. Quality control investigations by the National Weather Service have been performed with favorable results. The University of Illinois is currently verifying the accuracy of the rain gauges and the effects of splash out.

Instrument Location

For periods of operation and location of individual instruments see Figure 22.

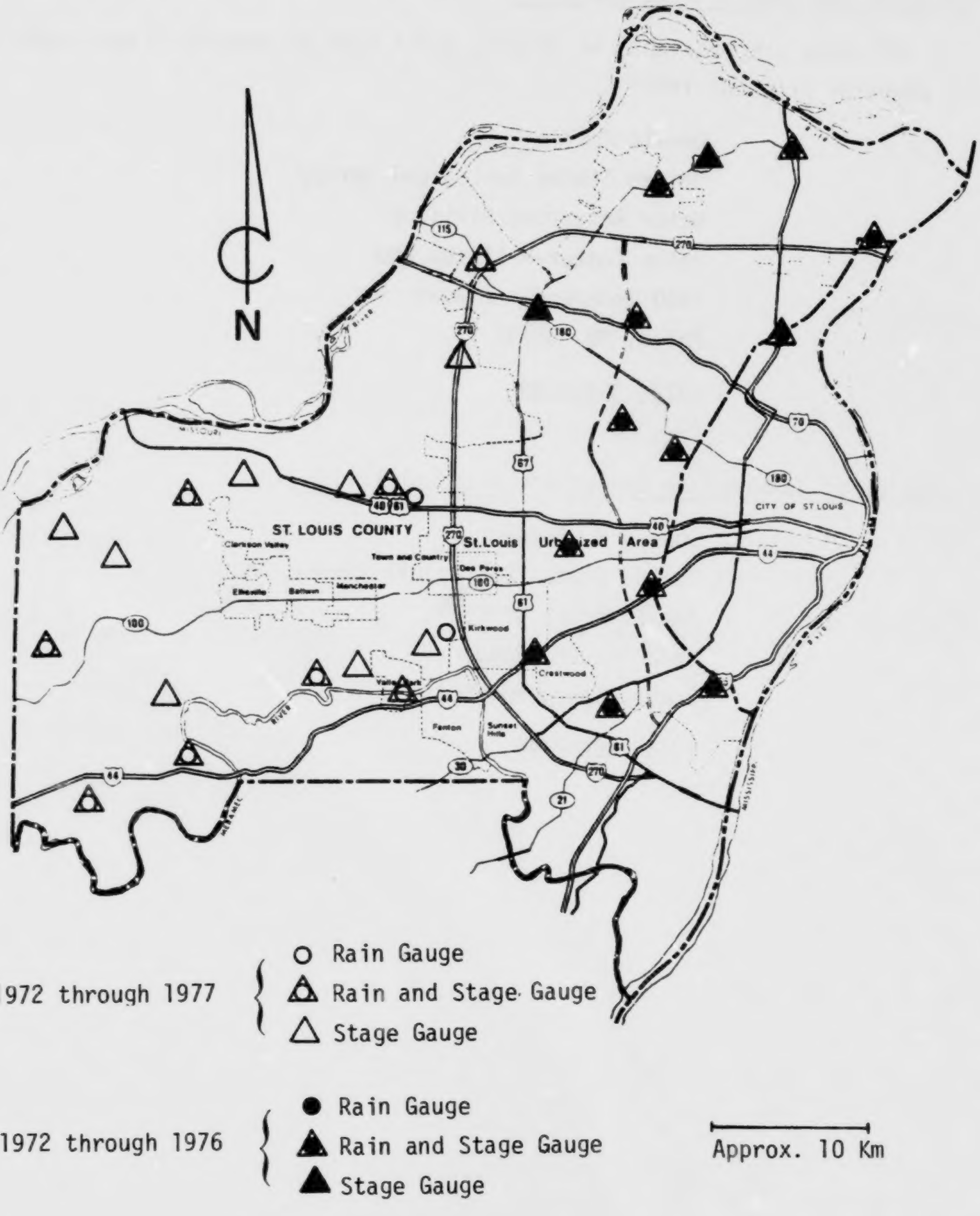

FIGURE 22. UNITED STATES GEOLOGICAL SURVEY RAINFALL AND RIVER STAGE MONITORING SITES

Location and Type of Data Available

All data are available on varying media such as magnetic tape, paper tape or computer printout from:

Donald Coffin
United States Geological Survey
Water Resources Division
Rolla Center-Mailstop 200
1400 Independence Road
Rolla, MO 65401

(314) 364-3680
Ext. 84

Location of Information Concerning Data Collection

Donald W. Spencer
United States Geological Survey, WRD
Sub-District Office
2222 Schuetz Road
Creve Coeur, MO 63141

(314) 268-7146

11.5.3 METROPOLITAN SEWER DISTRICT

Location

Six monitoring sites are scattered throughout the St. Louis Metropolitan Area (Figure 23).

Parameters Measured	Instrument/Method Used
Total Weekly Precipitation	Bendix 7750 weighing rain gauge recording to the nearest hundredth of an inch on a revolving drum. Before January 1976 a stick and cylinder rain gauge was used.

Observation Interval

Rainfall is monitored continuously and recorded weekly. Prior to January 1976, when the stick and cylinder rain gauges were in use, data were collected at irregular intervals. Observations were made prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

Visual inspection of the rain gauge and data are the only quality control procedures utilized.

Instrument Location

See Figure 23 for the locations of the six rainfall monitoring sites.

Location and Type of Data Available

Data are available on strip charts and summary sheets from Robert Nolte (address on following page).

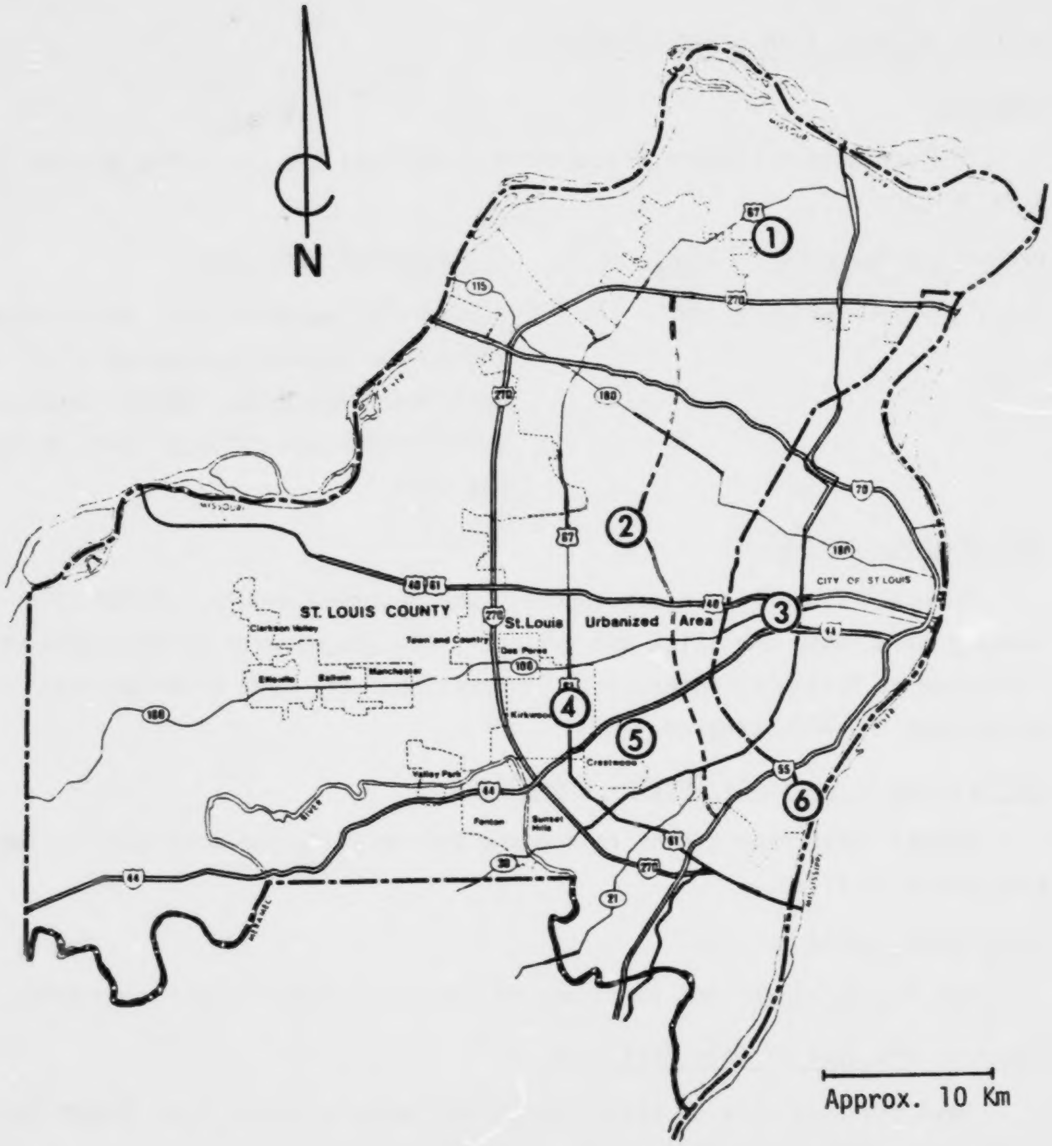

FIGURE 23 . METROPOLITAN SEWER DISTRICT RAINFALL MONITORING SITES

Location of Information Concerning Data Collection

Robert Nolte
Metropolitan Sewer District
1900 Sulfur
St. Louis, MO 63110

(314) 647-0700

12.0 RELATED INVESTIGATIONS

Introduction

Included in this category are investigations funded by the EPA as well as by other governmental agencies. The first section describes EPA-sponsored task order investigations performed under the RAPS contract, although some had no bearing on achieving RAPS goals.

The next sections describe the Metropolitan Meteorological Experiment (METROMEX) and the DA VINCI manned balloon flights, both of which were major investigations conducted in the St. Louis area and primarily funded by other governmental agencies.

The final section documents miscellaneous investigations, most of which produced results which relate to the RAPS objectives.

12.1 TASK ORDER INVESTIGATIONS

12.1.1 FLIGHT IMPACT ON STRATOSPHERIC AEROSOLS

Principal Investigator	Task Coordinator
George M. Hidy (formerly with)	William E. Wilson (MD-84)
C. Shepherd Burton (formerly with)	Environmental Protection Agency
Rockwell International	Environmental Sciences Research Laboratory
Air Monitoring Center	Research Triangle Park, NC 27711
11640 Administration Drive	(919) 541-2551
Creve Coeur, MO 63141	
(314) 567-6722	

Funding EPA Contract No. 68-02-1081, Task Order Nos. 11, 52

Periods of Performance

Task Order No. 11	July 1973 - October 1974
Task Order No. 52	October 1974 - June 1975

Summary

This task was a cooperative effort between the Department of Transportation (DOT) and the EPA. Its purpose was to investigate the significance of aircraft engine emissions on the aerosol population in the lower stratosphere. The photochemistry of SO_2 oxidation to form sulfate was to be emphasized with the key ingredient of the study being the development of the aerosol kinetic equation that would cover the evolution and growth of particles from the precursor formation to the aged size distribution. From the model size distribution calculations, an estimate would be made of the perturbation in the stratospheric aerosols created by aircraft engine emissions.

Although the DOT was specifically interested in the upper atmosphere, much of the work on both chemistry and physics in the development of an aerosol kinetic model would be applicable to the RAPS program as the modeling of sulfur pollutants, SO_2 and sulfate, were set at the top of the RAPS modelling effort. Consequently, this project was of interest to both the EPA and DOT.

The study can be divided into four principal elements:

1. The analysis of the chemical kinetics of aerosol precursor formation.
2. The development of an aerosol kinetic model to estimate changes in the particle size concentration distribution.
3. The analysis of the evolution of aerosols in the perturbed stratosphere.
4. The application to estimation of significance of aerosol behavior in the disturbed stratosphere.

The results discussed in the reports cover a brief review of aircraft and space vehicle emission inventories and the possible perturbation of the stratospheric aerosol. Disturbances resulting from injections of primary particles such as soot and aluminum oxide were considered along with secondary processes, including particulate sulfate formation from sulfur dioxide/nitrogen oxide oxidation. Other atmospheric reactions involving organic vapors and hydrochloric acid were also included. The evolution of aerosols was modeled using a kinetic equation limited to one spatial dimension. Assuming a simple turbulent convective diffusion model, the concentration of sulfate was estimated for the natural stratosphere and the stratophere disturbed in 1990 by illustrative aircraft traffic. The results derived from the sulfate vapor model were used to estimate the relative importance of new particle formation by hetermolecular nucleation and existing particle growth by condensation of sulfuric acid vapor. Finally, the sulfate precursor results were used to investigate the evolution of the stratospheric aerosol by a condensation growth -- Brownian coagulation -- gravitational fallout dominated kinetic mode. Time dependent solutions for the first and third moments of the size distribution were given, which indicate the aerosol distribution in the stratosphere should reach a quasi-steady state for periods exceeding a year, regardless of the origins of the particles.

Additional information and copies of the final reports may be obtained from the EPA Task Coordinator.

Publications

Burton, C. S. The Formation of Sulfuric Acid in the Stratosphere through the Gas Phase Oxidation of SO_2. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 11 Final Report, EPA Contract 68-02-1081. April 1975.

Hidy, G. M., J. P. Friend, J. Huntzicker, and A. W. Castleman Jr. Investigation of the Significance of Aircraft Engine Emissions on Stratospheric Aerosol. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 52 Final Report, EPA Contract 68-02-1081. July 1975.*

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*Served later as the basis for the completion of Chapter 6 of the Climatic Impact Assessment Program (CIAP) Monograph Volume III.

12.1.2 CAMP STATION OPERATION

Principal Investigator

Edward O. Nelson
Rockwell International
Air Monitoring Center
11640 Administration Drive
Creve Coeur, MO 63141

(314) 567-6722

Task Coordinator

Stanley L. Kopczynski (MD-47)
Environmental Protection Agency
Environmental Sciences Research
Laboratory
Research Triangle Park, NC 27711

(919) 541-3064

Funding EPA Contract No. 68-02-1081, Task Order No. 14

Period of Performance December 1973 - December 1974

Technical Approach

The Continuous Air Monitoring Program (CAMP) Station was located at 215 South 12th Street in St. Louis, Missouri and was operated by the U.S. Environmental Protection Agency's Quality Assurance and Environmental Monitoring Laboratory, Research Triangle Park, North Carolina. The station was officially opened on March 12, 1964 and monitored several gaseous pollutants on a continuous basis for almost eleven years. The last year of operation, January 1, 1974 to December 31, 1974, the station was operated by the Rockwell International Air Monitoring Center in support of the Regional Air Pollution Study (RAPS) to provide a reference base for the RAPS data and also to serve as an additional data source for cross-checking with the Regional Air Monitoring System (RAMS) then being installed in the St. Louis area.

Periods of Data Collection

Total oxidants, nitrogen dioxide, nitrogen oxide, sulfur dioxide, total hydrocarbons, methane, carbon monoxide, total suspended particulates and coefficient of haze were monitored throughout the period from March 1964 to December 1974. Oxides of nitrogen and ozone were monitored from 1972 to 1974. All gaseous analyzers were equipped with strip chart recorders from which a continuous record was obtained and a data logger which recorded on magnetic tape at five minute intervals.

Total Suspended Particulates	The high volume particulate sampler operated every third day with an active sampling period from 0000 - 2400 CST synchronized with the National Air Sampling Network schedule.
Gaseous Pollutant Samplers	All gaseous analyzers sampled continuously.

Parameters Measured	Instrument/Method Used
Total Oxidants	Beckman Speq. 6869 colorimetric analyzer - the output from the instrument was logarithmic with a sensitivity of 1 ppm at 90% of full scale.
Nitrogen Dioxide	Beckman Speq. 6869 colorimetric analyzer - the output was logarithmic with a sensitivity of 1 ppm at 90% of full scale.
Nitrogen Oxide	Beckman Speq. 6869 colorimetric analyzer - the output was logarithmic with a sensitivity of 1 ppm at 90% of full scale.
Sulfur Dioxide	Technicon Auto Analyzer, colorimetric - the output was logarithmic with a sensitivity of 1 ppm at 90% of full scale.
Total Hydrocarbons	Beckman Speq. 6869 hydrogen flame ionization analyzer - the output was linear to 20 ppm at full scale.

Parameters Measured	Instrument/Method Used (continued)
Methane	Beckman 108A hydrogen flame ionization analyzer - linear output to 20 ppm full scale.
Carbon Monoxide	Intertock A5611 non-dispersive infrared radiation absorption analyzer - linear output to 100 ppm full scale.
Oxides of Nitrogen	Bendix 8108-B chemiluminescence analyzer - linear output to 0.5 ppm full scale.
Ozone	Bendix 8002 chemiluminescence analyzer - linear output to 1 ppm full scale.
Total Suspended Particulates	General Metal Works high volume particulate sampler. Filters weighed to determine nitrates and sulfates. Results reported in $\mu g/m^3$. Weights were determined to the nearest miligram and airflow rates to the nearest 0.03 m^3/min.
Coefficient of Haze	AISI RAC F2-SES spot tape analyzer. The amount of light transmitted through darkened spots on a filter tape are compared to a clean section of the tape.

Calibration and Quality Control Procedures

General Metals Particulate Sampler	The samplers were calibrated when brushes or motors were changed. The flowmeters were calibrated with each brush or motor change. Motors and flowmeters were calibrated at the EPA laboratory at RTP with the ReF device used for calibrations and five

Calibration and Quality Control Procedures (continued)

General Metals Particulate Sampler (continued)	resistance plates. The results were corrected to standard conditions. Spare motors were kept in the field to replace the sampler motor when motor brushes needed replacing. The malfunctioning motor was returned to RTP for brush replacement and calibration.
Total Oxidant, Nitrogen Dioxide, Nitrogen Oxide and Sulfur Analyzers	Each instrument automatically initiated a purge cycle daily to establish a base line. The sulfur analyzer automatically reset itself to a preset base line when the drift was away from the set point. The rest of the analyzers were manually reset to a baseline when the drift was ± 2%. A monthly maintenance schedule was followed in which each instrument was completely dismantled, and cleaned, solution pumps calibrated and the photometers statically calibrated with optical filters. At approximately three month intervals the analyzers were dynamically calibrated by a team from RTP with the Bendix 8851 calibrator using calibrated permeation tubes. The calibrations were multipoint.
Total Hydrocarbon, Methane and Carbon Monoxide Analyzers	Each instrument was calibrated three times weekly with certified gases from Scott Research Labs. (CH_4 in ultrapure air and CO in N_2) Two point calibration - zero and span.

Calibration and Quality Control Procedures (continued)

Oxides of Nitrogen and Ozone Analyzers	These analyzers were calibrated monthly by a Bendix field representative utilizing the Bendix calibrator, calibrated permeation tubes and certified gases. The analyzers were manually zeroed daily and reset to the baseline in case of a ± 2% drift. Calibrations were multipoint.
AISI Spot Tape Sampler	The sampler established a base line every two hours and was manually reset when the drift was ± 2%. Calibrations were performed at approximately six month intervals.

The Bendix 8851 calibrator was calibrated in the EPA lab against chemical standards and certified gases before each field trip and checked in the field with chemical standards and a spectro photometer before field calibrations.

Location and Type of Data Available

The 1974 data generated at the CAMP station, exculuding the hi-vols, were recorded on strip charts and magnetic tape. Data are available on magnetic tape in SAROAD format from the RAPS Data Bank and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 514-4545

Publication

Nelson, E. O. Camp Station Operation. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 14 Final Report, EPA Contract 68-02-1081. June 1975.

12.1.3 CATALYST SULFATE STUDY DESIGN AND INSTALLATION

Principal Investigator	Task Coordinator
Edward P. Parry	Franz J. Burmann (MD-75)
Rockwell International	Environmental Protection Agency
Air Monitoring Center	Environmental Sciences Research Laboratory
2421A Hillcrest Drive	Research Triangle Park, NC 27711
Newbury Park, CA 91320	
(805) 498-6771	(919) 541-2106

Funding EPA Contract No. 68-02-1081, Task Order No. 23

Period of Performance March - December 1974

Summary

The possibility that catalytic converters installed on 1975 and later automobiles could cause increased oxidation of sulfur dioxide to sulfate prompted the EPA to conduct a field study. The purpose of this task order was to provide support to the EPA during the initial setup of this monitoring program.

This task order consisted of the following four subtasks:

1. To provide assistance in the design, selection, and acquisition of a suitable sampling location to monitor vehicular emissions in ambient air.
2. To collect and evaluate possible methods for determining the number and speed of vehicles passing the proposed site and formulate a recommendation for the best approach to measure these quantities.
3. To collect and evaluate all likely methods and recommend the best approach to the determination of the fraction of the total cars passing the site equipped with catalytic converters.

4. To collect and evaluate all data which have been previously obtained by other investigators for the Southern California area concerning ambient sulfate, particulate and sulfur dioxide levels. The methods by which the data were obtained were also to be evaluated.

To evaluate the effects of the catalytic converter under actual field conditions, a site was required where the ambient air containing the exhaust from a large number of automobiles could be measured. A location in California was required since California was the only state which required the installation of catalytic converters on new cars starting with the 1975 models. To satisfy more specific requirements, including traffic volume, definable wind flows, etc., a site near the junction of the San Diego-Santa Monica Freeways in West Los Angeles was selected. A review of methods available for determining car speed and count resulted in the recommendation that inductive loops implanted in the roadbed could be used. The best method for determining car mix (the fraction of total cars passing the monitoring site that were 1975 model year) appeared to be time lapse photography, however, this was relatively expensive. Consequently a method to estimate car mix from car registration data was developed. Finally, a complete review of existing data sources was made. Studies and data sources examined included the California State Air Resources Board-sponsored Aerosol Characterization Experiment (ACHEX) and Freeway Aerosol Study (FAS), the Los Angeles County Air Pollution Control District (LAAPCD), the National Aerometric Surveillance Network (NASN) and the Community Health and Environmental Surveillance System (CHESS).

For additional information and copies of the final report, contact the EPA Task Coordinator.

Publication

Parry, E. P. Catalyst Sulfate Study Design and Installation. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 23 Final Report, EPA Contract 68-02-1081. November 1975.

12.1.4 CATALYST 1 SULFATE STUDY SAMPLE ANALYSIS

Principal Investigator	Task Coordinator
Edward P. Parry Rockwell International Air Monitoring Center 2421A Hillcrest Drive Newbury Park, CA 91320	Franz J. Burmann (MD-75) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711
(805) 498-6771	(919) 541-2106

Funding EPA Contract No. 68-02-1081, Task Order No. 36

Period of Performance May - December 1974

Summary

Previous health studies by EPA have shown that there is a correlation between human health and level of particulate sulfate as determined by analyses for sulfate on high volume filters. The support supplied to EPA by this task order involved the chemical analyses of high volume and other filters and the analysis of ambient air bubbler solutions for SO_2. The source of the samples analyzed in this task order originated from the monitoring program that was designed in Task Order No. 23 (Section 12.1.3).

The sampling effort involved the use of five high volume samplers with both four and 24 hour samples, one 5-stage cascade sampler, and a membrane filter sampler. Of these filters, the high volumes were analyzed for total suspended particulates (TSP), sulfate, nitrate, and lead, while the other filters were analyzed for TSP only.

The methods used were specified by EPA as those described in the Federal Register, April 20, 1971. The TSP was determined by weight increase after proper conditioning of the exposed filter. The sulfate was determined by a colorimetric procedure using a barium methyl thymol blue complex and use of a Technicon Autoanalyzer. The nitrate method consisted of a reduction of nitrate to nitrite by a cadmium reduction, followed by coupling to form an azo dye. Colorimetric determination was again used with the employment of a Technicon Autoanalyzer. An atomic absorption method was used for lead.

While the analytical methods were furnished by EPA, the details of the procedures were developed to give reliable, rapid and efficient semi-automated methods of analyses. Some of the more significant changes involved a modification of the Technicon to double the sample output from the sampler and linearizing the analytical relation (signal vs. concentration) for the sulfate procedure. In addition, an internal and external quality assurance program was initiated. The internal quality assurance involved analysis of blanks, duplicates, standards, and spiked samples and the use of quality control charts to ensure that the analytical procedures stayed in control.

The external quality control involved analyses of unknown samples submitted by EPA and the analysis of aliquots of the same filter by both Rockwell and EPA. Correlation coefficients for the agreement between EPA and Rockwell results for TSP, sulfate, and nitrate were better than 96%. The agreement for the lead results were not as good.

During the contractual period over 1300 high volume filters, 435 membrane filters, 86 cascade samplers, and 406 SO_2 bubblers were analyzed. The data were submitted to the EPA Task Coordinator at Research Triangle Park on SAROAD cards. Copies of the final report and additional information may be obtained from the EPA Task Coordinator.

Publication

Parry, E. P. Assist in the Sampling and Analysis in the Catalyst 1 Sulfate Study. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 36 Final Report, EPA Contract 68-02-1081. April 1975.

12.1.5 VISIBILITY MODEL DEVELOPMENT

Principal Investigator	Task Coordinator
L. Willard Richards (formerly with)	William E. Wilson (MD-84)
Rockwell International	Environmental Protection Agency
Air Monitoring Center	Environmental Sciences Research Laboratory
2421A Hillcrest Drive	Research Triangle Park, NC 27711
Newbury Park, CA 91320	
(805) 498-6771	(919) 541-2551

Funding EPA Contract No. 68-02-1081, Task Order No. 28

Period of Performance October 1974 - August 1975

Summary

The purpose of this task order was to statistically examine the data from the Aerosol Characterization Experiment (ACHEX), sponsored by the California State Air Resources Board, to determine what atmospheric parameters or combination of atmospheric parameters correlate with visibility reduction as measured by b_{scat}, and to contribute to the development of simulation models of air pollution processes. The analysis was based on the continuous instrument data for local meteorological conditions and the concentrations of the important pollutant gases collected in the Los Angeles South Coast Air Basin.

Two statistical methods were used to analyze the data: The Automatic Interaction Detector (AID) which successively splits the data so as to obtain a maximum reduction in variance, and multiple linear regression analyses. The regression analyses were carried out using the computer routines from the IBM Scientific Subroutine Package for the System 360, and included stepwise regressions as well as regressions with a variety of preselected independent variables.

Ozone showed the strongest correlation with visibility reduction (b_{scat}). The only other parameters to show significant positive correlations were the

hydrocarbon concentrations, with methane second only to ozone in the strength of the correlation. There was little or no correlation between visibility reduction and the concentrations of SO_2, CO and NO_2. There was a negative correlation between b_{scat} and the condensation nuclei concentration. These results were based primarily on the data from 18 selected days.

In contrast to smog chamber results, it was found that the maximum visibility reduction often occurred about three hours ahead of the ozone maximum, and almost never occurred at a later time.

These data supported the importance of photochemical reactions of hydrocarbons in visibility reductions and it was also recommended that methane concentrations be included in future hydrocarbon and field studies.

The final report and a copy of the data base on magnetic tape was submitted to the EPA Task Coordinator. Copies of the report and additional information may be obtained from the EPA Task Coordinator. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Richards, L. W., Visibility Model: Correlation of Light Scattering with Other Atmospheric Parameters. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 28 Final Report, EPA Contract 68-02-1081. May 1976.

12.1.6 ARGONNE RADIOMETER OPERATION

Principal Investigator	Task Coordinator
Edward O. Nelson Rockwell International Air Monitoring Center 11640 Administration Drive Creve Coeur, MO 63141 (314) 567-6722	Ronald K. Patterson (MD-57) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-2254

Funding EPA Contract No. 68-02-2093, Task Order Nos. 117 and 102

Period of Performance July 1976 - April 1977

Technical Approach

In cooperation with Argonne National Laboratory, the Environmental Protection Agency provided for the operation and maintenance of a silicon cell pyranometer at RAMS Site 124 from July 1, 1976 through February 14, 1977 and at RAMS Site 125 from February 15 to April 8, 1977.

Period of Data Collection

Pyranometer data were continuously recorded on strip charts from July 1, 1976 to April 8, 1977.

Parameters Measured	Instrument/Method Used
Direct, diffuse and total solar radiation (irradiance)	Silicon cell pyranometer (dichopyranometer) and strip chart recorder. (watts/meter^2)

Calibration and Quality Control Procedures

Other than the initial calibration, no calibrations were performed on the pyranometer. Weekly maintenance consisted of cleaning the diffuser and insuring that the strip above the sensor was rotating.

Quality control will consist of inspecting the strip charts for errors during reduction.

Location and Type of Data Available

Completed radiometer charts were periodically sent to Argonne National Laboratory for reduction. Additional information and copies of the data in the form of strip charts may be obtained from:

Marvin L. Wesely
Argonne National Laboratory
Atmospheric Physics Section
9700 South Cass Avenue
Argonne, Illinois 60439

(319) 739-7711
Ext. 2357 or 3738

Publication

No final report was required for Task Order No. 117. The description of the radiometer operation is included in the following report.

Nelson, E. O. Dichotomous Aerosol Sampling System. Rockwell International Air Monitoring System, Creve Coeur, Missouri. Task Order No. 102 Final Report, EPA Contract 68-02-2093. April 1979. EPA-600/4-79-024.

12.1.7 COBB/ANDRUS PLUME STUDY PIBAL SUPPORT

Principal Investigator	Task Coordinator
Joseph A. Strothmann	Jack L. Durham (MD-57)
Rockwell International	Environmental Protection Agency
Air Monitoring Center	Environmental Sciences Research Laboratory
11640 Administration Drive	Research Triangle Park, NC 27711
Creve Coeur, MO 63141	
(314) 567-6722	(919) 541-2181

Funding EPA Contract No. 68-02-2093, Task Order No. 126

Period of Performance May - June 1977

Technical Approach

In May 1977 the Electric Power Research Institute (EPRI), as part of the Sulfate Regional Experiment (SURE), conducted a point source plume study to examine aerosol transformation and transport. The Environmental Protection Agency cooperated in this effort by providing two mobile pilot balloon (pibal) teams to define the low level wind fields.

The two mobile pibal teams collected single theodolite pibal data at the Cobb Power Plant in Muskegon, Michigan and at the Andrus Power Plant near Greenville, Mississippi. Pibals were released during selected periods with real time data from one mobile unit being transmitted to the field manager. This allowed the coordination of instrumented aircraft flights and the selection of subsequent pibal release sites.

Periods of Data Collection

Pibals were released at irregular intervals during the following periods selected by the field manager:

May 15 - 20, 1977	Muskegon, Michigan
May 25 - 30, 1977	Greenville, Mississippi

Parameters Measured	Instrument/Method Used
Wind speed and wind direction	Single theodolite method. Calculated wind speed and direction from angular values observed at a constant time interval of 30 seconds.

Calibration and Quality Control Procedures

Except for the minimum observation being five minutes (weather permitting), all pibals were released in accordance with Upper Air Sounding Network procedures (Section 4.0). For agreement with the RAPS pibal reduction computer program, the theodolites were oriented to 180° when aimed at true north. Magnetic north was obtained by compass and corrected to true north by applying the isogonic correction value from the latest sectional aeronautical chart. Quality control procedures included reviewing elevation and azimuth angles for angular continuity and checking for correct magnetic declination. Theodolite orientation was checked before and after each release. Theodolites were checked and collimated prior to the study period.

Location and Type of Data Available

Copies of the final report and additional information may be obtained from the EPA Task Coordinator. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Winkler, B. D. Cobb/Andrus Plume Study Pibal Support. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 126 Final Report, EPA Contract 68-02-2093. July 1977.

12.1.8 COBB/ANDRUS/BREED PLUME STUDY PIBAL SUPPORT

Principal Investigator	Task Coordinator
Joseph A. Strothmann	Francis A. Schiermeier (MD-84)
Rockwell International	c/o Environmental Protection Agency
Air Monitoring Center	Environmental Sciences Research Laboratory
11640 Administration Drive	Research Triangle Park, NC 27711
Creve Coeur, MO 63141	
(314) 567-6722	(919) 541-2649

Funding EPA Contract No. 68-02-2093, Task Order No. 130

Period of Performance October - November 1977

Technical Approach

The Electric Power Research Institute (EPRI) as part of the Sulfate Regional Experiment (SURE) conducted a point source plume study to examine aerosol transformation and transport. By injecting a conservative tracer, sulfur hexafluoride (SF_6), into the power plant stack to label a segment of the plume, the rate processes acting on aerosols and aerosol precursor gases were studied. The Environmental Protection Agency assisted in this effort by providing two mobile pilot ballon (pibal) teams to define low level wind fields.

The two mobile pibal teams collected single theodolite pibal data at the Cobb Power Plant in Muskegon, Michigan, the Andrus Power Plant near Greenville, Mississippi and the Breed Power Plant in Terre Haute, Indiana. Real time data transmission from one mobile unit allowed the coordination of instrumented aircraft flights and the selection of subsequent pibal sites.

Periods of Data Collection

Pibals were released at irregular intervals during the following periods selected by the field manager:

October 21 - 26, 1977	Greenville, Mississippi
November 4 - 14, 1977	Terre Haute, Indiana
November 17 - 22, 1977	Muskegon, Michigan

Parameters Measured	Instrument/Method Used
Wind speed and wind direction	Single theodolite method. Calculated wind speed and direction from angular values observed at a constant time interval of 30 seconds.

Calibration and Quality Control Procedures

All pibals were released in accordance with Upper Air Sounding Network procedures (Section 4.0) with the exception of the minimum observation being five minutes (weather permitting). For agreement with the RAPS pibal reduction computer program, the theodolites were oriented to 180° when aimed at true north. Magnetic north was obtained by compass and corrected to true north by applying the isogonic correction value from the latest sectional aeronautical chart. Quality control procedures included reviewing elevation and azimuth angles for angular continuity and checking for correct magnetic declination. Theodolites were checked and collimated prior to the study period. Orientation was checked before and after each release.

Location and Type of Data Available

Copies of the final report and additional information may be obtained from the EPA Task Coordinator. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Arbuthnot, D. A. Cobb/Andrus/Breed Plume Study Pibal Support. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 130 Final Report, EPA Contract 68-02-2093. December 1977.

12.1.9 AEROSOL EFFECTS ON VISUAL RANGE

Principal Investigator	Task Coordinator
R. Lee Myers (formerly with) Rockwell International Air Monitoring Center 11640 Administration Drive Creve Coeur, MO 63141 (314) 567-6722	Francis Pooler (MD-84) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-2649

Funding EPA Contract No. 68-02-2093, Task Order No. 127

Period of Performance May 1977 - October 1978

Summary

The purpose of Task Order 127 was to assess and then analyze data collected during the RAPS in terms of the correlation between aerosols and visibility. The effort was originally conceived and funded as a four task project. Task A was to locate and describe the available relevant data. Task B was to provide validation of the nephelometer data and then to analyze that data in terms of temporal and spatial patterns.

In Task C, the nephelometer data were to be correlated with the data from other aerosol measurements, particularly high volume samplers and the Lawrence Berkeley Laboratory (LBL) dichotomous samplers. Task D called for a correlation of the nephelometer data with the visual range data from Lambert-St. Louis International Airport with special emphasis on the influence of relative humidity and sulfates.

Due to the limitation of funds in the twilight hours of RAPS and the inability of Lawrence Berkeley Laboratories to provide the chemical analysis data in a timely fashion, Task Order 127 was aborted before completion.

Interim completion reports were prepared for Tasks A and B. However, Tasks C and D were only partially completed, and no reports were prepared.

Publications

Arbuthnot, D. A. Aerosol Effect on Visual Range. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 127A Completion Report, EPA Contract 68-02-2093. July 1977.

Myers, R. L. and D. A. Arbuthnot. Aerosol Effects on Visual Range. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 127B Completion Report, EPA Contract 68-02-2093. October 1977.

12.2 METROPOLITAN METEOROLOGICAL EXPERIMENT (METROMEX)

Introduction

One of the reasons that led to the selection of the St. Louis Metropolitan Area as the study site for RAPS was the availability of historical data. St. Louis had already been the site for several air pollution investigations. Project METROMEX, conducted from 1971 through 1975, was a major meteorological study initiated prior to RAPS.

METROMEX was conducted by investigators from Argonne National Laboratory, Battelle Pacific Northwest Laboratories, University of Chicago, Illinois State Water Survey, NOAA Wave Propagation Laboratory, Stanford Research Institute, and University of Wyoming. The University of California at San Diego and the University of Missouri at Rolla were allied participants. The overall goal of the project was to investigate inadvertent weather modification caused by the St. Louis urban-industrial complex with emphasis on urban-related alterations in precipitation processes and quantitative changes in surface precipitation.

The research objectives of the project were:

1) To study the effects of the urban environment upon the frequency, amount, intensity and duration of precipitation and related severe weather;
2) To identify the physical processes of the atmosphere which are responsible for producing the observed urban weather effects;
3) To isolate the factors of the city complex which are the causative agents of the observed effects; and
4) To assess the impact of urban induced inadvertent weather changes upon the wider issues of society.

The principal investigators of METROMEX assembled several times each year to exchange data, discuss results, revise work plans and combine efforts for maximum effectiveness. Week-long scientific conferences were held each fall (1971-1974) and in the spring (1975) when project scientists, support staff and representatives of sponsoring agencies reviewed past accomplishments and planned for their continuing field studies.

Funding

The funds for METROMEX and its participants were provided by the National Science Foundation, the Energy Research and Development Administration (formerly the Atomic Energy Commission), the State of Illinois, and the U. S. Environmental Protection Agency.

Period of Performance

Although some experiments were conducted on a year-round basis, the primary study periods for METROMEX in the St. Louis area were during the summer months of 1971 through 1975.

Summary

Argonne National Laboratory. The Argonne National Laboratory participated in the first three years of METROMEX. During the summer of 1971, two extensive areas of study were airflow characteristics and rain scavenging. Objectives of the airflow characteristics study were:

a. to investigate the thermally-induced pressure force differences causing a city air circulation;

b. to investigate the effects of frictional force differences, arising from the dissimilarity in the characteristic roughnesses of the city and rural surfaces, modifying the direction and speed of the mean wind and turbulence intensity.

To accomplish these objectives, double theodolite pibal observations and airborne measurements of meteorological parameters (temperature, dew point, wind direction and speed) were conducted.

Objectives of the rain scavenging studies were to improve the prediction and understanding of the rain scavenging of atmospheric particulate matter.

Aerosol samples (both surface and airborne), daily rain samples, and sequential rain samples were collected for the rain scavenging studies.

For the summer 1972 field studies, an acoustic sounder was used, supported by meteorological observations, both surface and aloft. The objectives for the summer studies were:

a. to observe the temporal and spatial variations of lower atmospheric inversion structures near a large city and to determine the influences of the urban area upon them;
b. to study the density structure of the lower atmosphere both upwind and downwind of the city (and possibly observe the city plume);
c. to compare the presence of temperature inversions detected by the acoustic sounder with the distribution of airborne particulates detected by the Stanford Research Institute lidar system;
d. to study the morning break-up of a nocturnal inversion by continuously observing the changing inversion height as indicated by the acoustic sounder; by periodically measuring the inversion intensity and height by radiosonde flights at hourly intervals; and by comparing the nocturnal inversion break-up recorded by the acoustic sounder with the development of the daytime mixing layer as detected by the lidar instrument.

The acoustic sounder experiment was expanded into a network in 1973 by the addition of two more units. This network of acoustic sounders made it possible to observe the urban and rural differences of the height and time behavior of inversion layers, plus providing information of the urban effects on passing thunderstorms. The meteorological support was increased by the addition of the WHAT (winds, height, and temperature) system, a semi-automatic radiosonde and double-theodolite balloon-tracking apparatus developed for the measurement of wind and temperature profiles through the planetary boundary layer.

Battelle Pacific Northwest Laboratories. During August 1971, Battelle Pacific Northwest Laboratories conducted several field studies as part of METROMEX. Studies included airborne air sampling and tracer materials released into the atmosphere and later collected in rainwater samples. During August 1972 and 1973, three separate studies were carried out. The first being a tracer scavenging study of convective storms; second, an aerosol size distribution study; and third, measurements of rain scavenging of pollution generated by the metropolitan area.

The July and August 1974 experiments dealt with the evolution of aerosol size distribution study. Their objectives were to provide an input into a mathematical air pollution model and to determine the mechanisms of physical and chemical charges which may occur in a pollutant between the point of release and a receptor downwind. To satisfy these objectives, an instrumented aircraft measured aerosol particle size distribution as a function of time in a parcel of air, and also the concentration of Aitken nuclei in an air sample. In order to follow the time evolution of the particle size distribution in a given parcel of air, a tetroon was released to a constant altitude, and its path intersected by the aircraft at different times, obtaining downwind measurements.

Three separate studies took place during July and August of 1975; aerosol and trace gas transformations, tracer releases into convective storms, and the transport and deposition of pollutants downwind of St. Louis. The objective of the aerosol and trace gas transformations study was to determine the physical and chemical changes of pollutants in the St. Louis plume. The investigation was conducted in a Lagranian frame of reference using the Battelle instrumented aircraft. Measurements of aerosol particle size distribution, concentration of Aitken particles, ozone, nitric oxide, nitrogen dioxide, sulfur dioxide, several particle size distributions and turbidity at different altitudes were made to determine the relationships between them. A multiwavelength sunphotometer was employed to measure solar intensities in five narrow wavelength bands and one broad wavelength band; turbidities were determined for each of the wavelength bands. Additional observations were carried out on the ground to examine changes in particulate loading with respect to meteorological conditions.

Inert tracers were released at sequential altitudes near the sides of convective storms in the St. Louis area. The purpose of the tracer release was to determine the extent to which the particulate contaminants in the entrained air were being scavenged by the precipitation, and to obtain information on the trajectories of particulates entrained into the clouds at known locations. Following the tracer releases, samples of rain were collected using a network of 219 rain collectors. These samples were frozen using dry ice and returned to the laboratory where they were analyzed for the tracers and other elements using instrumental neutron activation.

The third study involved the collection of air samples upwind, in, and downwind of St. Louis to determine the concentrations of contaminants produced by the St. Louis metropolitan area and to define the rate of decrease in contaminant concentrations downwind of St. Louis due to atmospheric mixing, dry deposition on the earth's surface, and in some cases, chemical conversion processes. A grid of air sampling ground stations was developed for data collection. The Battelle aircraft collected air samples at three elevations in the mixed layer above the downwind air sampling stations. The air samples were then analyzed for sulfur dioxide, sulfates, carbon monoxide, fluorocarbons, and trace elements at the laboratory.

University of Chicago. The University of Chicago participated in all five years of METROMEX. During July and August of 1971, cloud physics studies were conducted using radar observations and airborne measurements. Their four main objectives were:

a. to measure cloud condensation nuclei and ice nuclei to determine if the city effluent is a source for the nuclei;
b. to measure cloud drop spectra to determine whether the clouds over or downwind of the city differ from those upwind, and if this difference is related to the nuclei measurements;
c. to map precipitation using a height-finder radar;
d. to measure the size and extent of the city plume as it is revealed through temperature, relative humidity and aerosols.

To achieve these objectives, an AN/TPS-10, three centimeter, range height indicator radar and an SPS-4, five centimeter radar were utilized for mapping precipitation. Delineation of the city plume was accomplished using airborne measurements. Aircraft were used to study cloud drop spectra, cloud condensation nuclei, ice nuclei, and cloud particle spectra (both liquid and solid).

The final four years of involvement in METROMEX were similar to those of the field studies conducted the first year, except that pibal observations were performed during July and August of 1973.

Illinois State Water Survey. The Illinois State Water Survey was involved in the entire five year METROMEX project. They developed and maintained the project's field headquarters at Pere Marquette State Park in Illinois. The Survey's three basic objectives for the five year study were:

a. to study severe local weather phenomena (heavy rainstorms, thunderstorms, and hailstorms) in order to describe the temporal and spatial relationships of these events in the St. Louis urban area with special reference to these relationships under varying synoptic conditions;
b. to study rainfall and radar data to assess the magnitude and location of urban-related precipitation changes with specific reference to time-space analyses of rainfall and synoptic weather analyses;
c. to conduct an atmospheric tracer study involving placement of a unique chemical tracer into convective storms, and provide subsequent analysis to determine the temporal and spatial distribution of the tracer at the surface following its interaction with the precipitation process.

During the summer of 1971, the Survey began operation of a precipitation, severe weather network. Included were measurements of rain, hail, thunder, atmospheric electricity, rain drop spectra, temperature, relative humidity, wind direction and speed. Two radar systems were utilized along with time-lapse cloud photography. Rare tracer materials were released both at the surface and aloft into storm updrafts and then measured in a network of rain-water collectors. Aircraft cross-sectional measurements were made of low-level temperature, relative humidity, and aerosols throughout the urban and rural areas. Pibal observations were used to delineate the low-level wind fields. The surface rain gauges and weather networks remained in year-round operation for the duration of METROMEX. In 1972, the rain gauge and hail-pad network was expanded to permit the delineation of the rainfall and any possible alterations in the more distant downwind areas of St. Louis and to gain a better definition of thunderstorm intensity at the boundaries of the 1971 network. The raindrop size and chemical sampling studies, the hygro-thermograph network, and the upper air observations were also expanded during 1972. During the remaining three years (1973, 1974 and 1975), the field studies were basically similar to those conducted during 1972.

National Oceanic and Atmospheric Administration/Environmental Research Laboratories (NOAA/ERL) Wave Propagation Laboratory. During July and August 1975, the NOAA/ERL Wave Propagation Laboratory performed three-dimensional wind field measurements using their dual-doppler radar to study high resolution wind patterns over the urban and surrounding rural areas. The radar system was composed of two coherent, X-band radars which were coordinated to scan in common tilted planes through the radar echo. When precipitation particles were not available as tracers of the air motion, X-band chaff was released either from aircraft or from the ground.

On a few occasions, fixed beam high resolution data were taken to determine the one-dimensional wave number spectrum of the radial velocity component. From this data and the variance of the Doppler spectrum, estimates were made of the eddy dissipation rates under a variety of conditions.

The following were the objectives of the NOAA/ERL Wave Propagation Laboratory's field studies for 1975:

a. to observe the rural-urban difference in the wind field within the mixing layer under a variety of environmental stability and wind conditions;
b. to observe the wind field within convective storms as they pass through the urban area with the intention of documenting city-induced changes in the storm kinematics;
c. to apply both of the above in an evaluation of existing numerical models of the urban mixing layer and convective storms; and
d. to provide other METROMEX participants with high resolution measurements of the three-dimensional urban wind field that had been previously unattainable.

Stanford Research Institute. During August 1971, the SRI/EPA Mark VIII lidar system was used to investigate and record the urban aerosol structure over St. Louis. The lidar observations were used to provide quantitative data on aerosol structural features (gradients of relative aerosol concentration, layer height, etc.) that may reveal atmospheric dynamic, physical, and radiative processes important in air pollution problems. In August 1972, the primary data-gathering instrument was the SRI Mark IX lidar system. In addition to the lidar observations of aerosol structure, other data were collected to extend the lidar observations in a quantitative sense, to derive or verify relationships governing the interaction of urban aerosols with the transfer of solar and terrestrial radiation, and to investigate urban effects on thermal stability and convection. A complementary SRI program during August 1972 was the investigation of the role of surface geophysical characteristics in determining urban-rural differences in the surface energy budget. As a part of this study, aircraft observations of ambient dry and wet bulb temperatures, downwelling and upwelling solar radiation, surface radiative temperature, and panchromatic surface photographs were made at two to three hour intervals.

The lidar system was incorporated with additional instrumentation in a van for the field studies of July and August 1973. An integrating nephelometer for measurement of near-surface aerosol content, a solar radiometer viewing a 90° vertical atmospheric sector, and dry and wet bulb temperature sensors supported the lidar data collection. Other instrumentation used at a fixed site were a multiwavelength sunphotometer for the observation of solar intensities, a pyheliometer for observing the wavelength-integrated solar intensity, a pyranometer for observing the wavelength integrated solar flux, a digital data acquisition system to record the output of the preceding sensors at one-minute intervals, and a Nuclepore filter sampler to collect suspended particulate matter for analysis of aerosol physical and optical properties.

During August 1974, SRI participated in collaboration with the University of Wyoming and the National Center for Atmospheric Research flight facility to obtain airborne observations along a flight track over St. Louis during two complete diurnal cycles. These airborne observations included solar irradiance (both downwind and upwind), surface radiometric temperature, zenith sky radiance, air temperature, dew point, horizontal winds (Doppler), and daytime surface photography.

SRI concentrated on mobile data collection for their July and August 1975 studies using their Mark IX mobile lidar van augmented with additional sensors to derive the temporal and spatial contours of near-surface aerosol density, temperature, and relative humidity. This lidar program was coordinated with the University of Wyoming and the University of Chicago aircraft flights. In addition, two sodar units were operated at fixed sites to provide further information on mixing depth and convective activity. An array of solar flux radiometers were used to derive urban/rural variations in surface heating and to study mid-day surface heating effects on afternoon aerosol distributions, cloud formation, and precipitation amounts.

University of Wyoming. The University of Wyoming, during its five year participation in METROMEX, pursued the following objectives:

a. to observe and analyze the kinematics of the general meso-scale motion in an urban area;
b. to investigate the temporal and spatial variations of the static meteorological parameters in the urban environment and relate the observed air mass modification to energy, moisture, and aerosol (Aitken nuclei) budgets in the urban atmosphere;
c. to observe and analyze the character and modification of life cycles of growing cumulus and cumulonimbus clouds due to the meso-scale influences (heat, moisture, and aerosol ingestions) of an urban area; and
d. observe and analyze the time variations of heat, moisture, and particulate distributions in the urban atmosphere together with the rural-urban variations in solar and IR radiation and to relate to the energy budget of the urban area.

During August 1971 the University of Wyoming obtained samples and measurements using airborne, mobile, and observing units. Airborne measurements were made of temperature, dew point, liquid water content, turbulence, cloud nuclei spectra, aerosols, size distribution of water droplets, and Aitken nucleus concentrations. Mobile units made observations of temperature, dewpoint, wind direction and speed, atmospheric pressure, ice nuclei, raindrop size distribution, rate of rainfall, rain and hail amounts. Single theodolite pibals were also observed by the mobile units. The observing units consisted of four double theodolite pibal teams provided by the United States Air Force Air Weather Service. The four teams also made hourly meteorological surface observations. For the August 1972 field experiments, the upper air sounding network was expanded to include three sources for upper air data. One source was a NOAA operated radiosonde station; the second was a radiosonde station operated by University of Wyoming personnel; and third, the University of Wyoming aircraft obtained soundings of the vertical profile. The field experiments for August 1973, July and August of 1974 and 1975 were similar to those conducted during August of 1971 and 1972

University of California at San Diego. Allied with METROMEX, the University of California at San Diego conducted an airborne visibility study in the St. Louis area collecting airborne and ground-based measurements for a 15 day period during August 1971. Airborne measurements collected were:

a. Lower Hemisphere Radiance Distributions
b. Upper Hemisphere Radiance Distributions
c. Atmospheric Scattering Coefficients
d. Horizontal Path Function Radiances
e. Irradiance Levels, Upwelling and Downwelling
f. Temperature, Pressure, and Dewpoint
g. Atmospheric Scattering Coefficient Profile
h. Vertical Path Function Radiances
i. Irradiance Profile, Upwelling Only

Ground-based measurements collected were:

a. Atmospheric Scattering Coefficient
b. Sky and Terrain Radiances
c. Atmospheric Scattering Coefficient
d. Apparent Solar Radiance
e. Sky Radiance Distribution

University of Missouri at Rolla. Also allied with METROMEX during August 1973, the University of Missouri at Rolla collected airborne aerosol size measurements using a Climet CI 201/205 particle analyzer/counter sampling in two size bands. Dew points were continuously recorded by a Technology/Versatronics thermoelectric dewpoint hygrometer.

Location of Information Concerning Data Collection. Additional information may be obtained by contacting the participants of Project METROMEX.

Publications

Numerous publications resulted from METROMEX. The following is a partial list as only the operational reports were used to prepare this summary.

Changnon, S.A., Jr. 1971 Operational Report for METROMEX. Illinois State Water Survey, Urbana, Illinois. November 1971.

Lowry, W.P. 1972 Operational Report for METROMEX. Illinois State Water Survey, Urbana, Illinois. April 1973.

Lowry, W.P. 1973 Operational Report for METROMEX. Illinois State Water Survey, Urbana, Illinois. December 1973.

Braham, R.R., Jr. 1974 Operational Report for METROMEX. University of Chicago, Chicago, Illinois. December 1974.

Auer, A.H., Jr. 1975 Operational Report for METROMEX. University of Wyoming, Laramie, Wyoming. November 1975.

12.3 DA VINCI II AND III MANNED BALLOON FLIGHTS

Introduction

Project DA VINCI consisted of a series of instrumented ballon flights to study the long range transport and transformation of air pollutants. Interest was focused on the ways in which gaseous effluents from urban industrial and power production activities are slowly transformed into more hazardous pollutants in the lower atmosphere. Two 24 hour flights were flown in late spring and early summer from Arrowhead Airport, 24 kilometers west of St. Louis (flight paths are shown in Figures 24 and 25). The St. Louis area was selected because it was the site of the EPA's Regional Air Pollution Study (RAPS). As a result of the study, St. Louis, its industry and its major power production facilities had been well characterized. In addition, the Regional Air Monitoring System (RAMS) established as part of RAPS would provide valuable data for the interpretation of DA VINCI results.

The project was joint effort of the Department of Energy (DOE) (formerly the Energy Research and Development Administration), DOE's Sandia Laboratories, the National Geographic Society, the National Oceanic and Atmospheric Administration (NOAA), and the Environmental Protection Agency (EPA). Along with the major participants listed above, several other Federal agencies, national laboratories, and universities were involved in the research effort. These institutions include: Argonne National Laboratory, Brookhaven National Laboratory, Lawrence Berkeley Laboratory, Lawrence Livermore Laboratory, and Los Alamos Scientific Laboratory; the U. S. Army Atmospheric Sciences Laboratory (White Sands Missile Range, New Mexico); the Institute for Storm Research; Washington University; Washington State University; University of Texas at El Paso; the Research Triangle Institute; AeroVironment, Incorporated; and Grumman Houston Corporation.

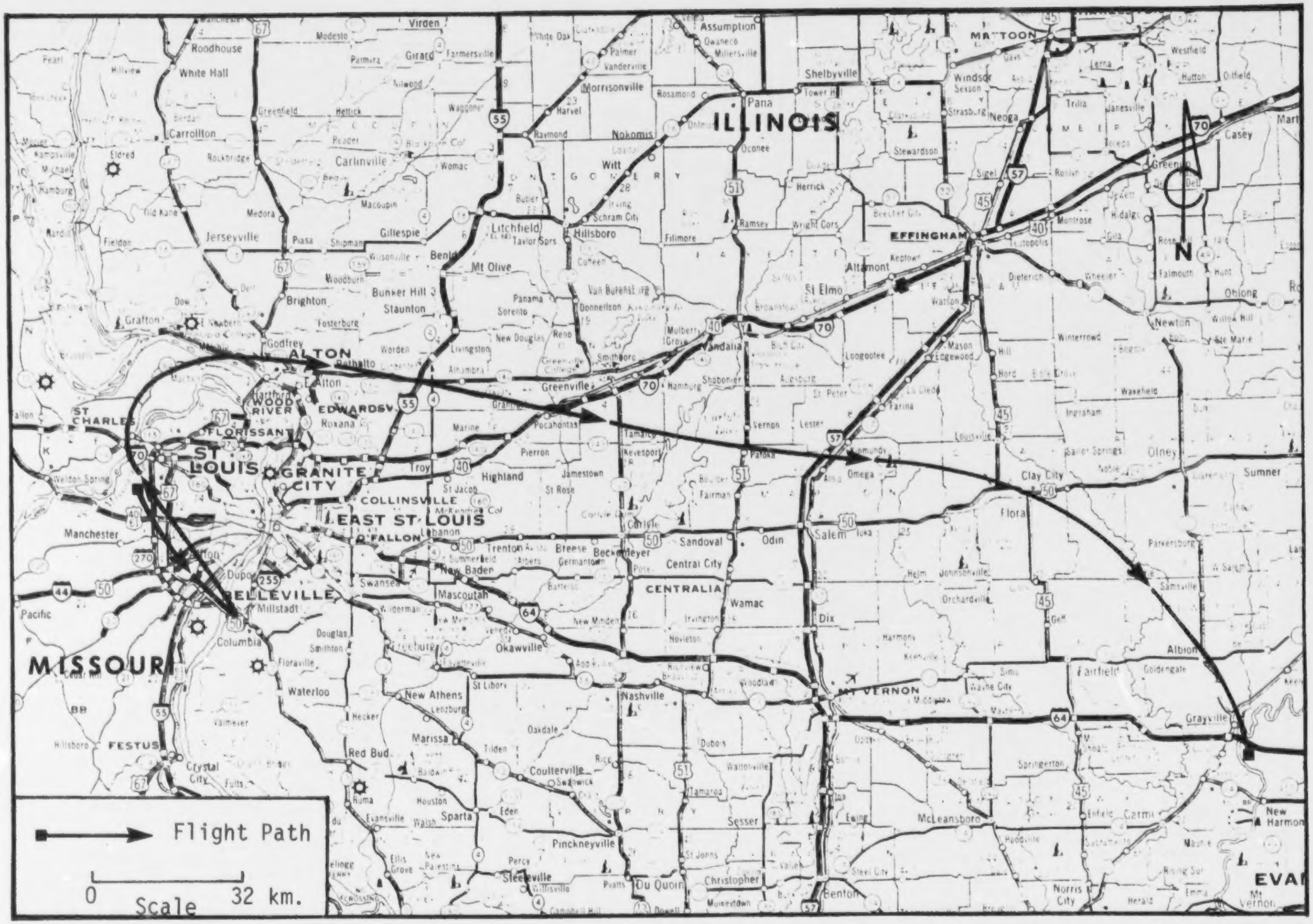

FIGURE 24. APPROXIMATE FLIGHT PATH OF DA VINCI II

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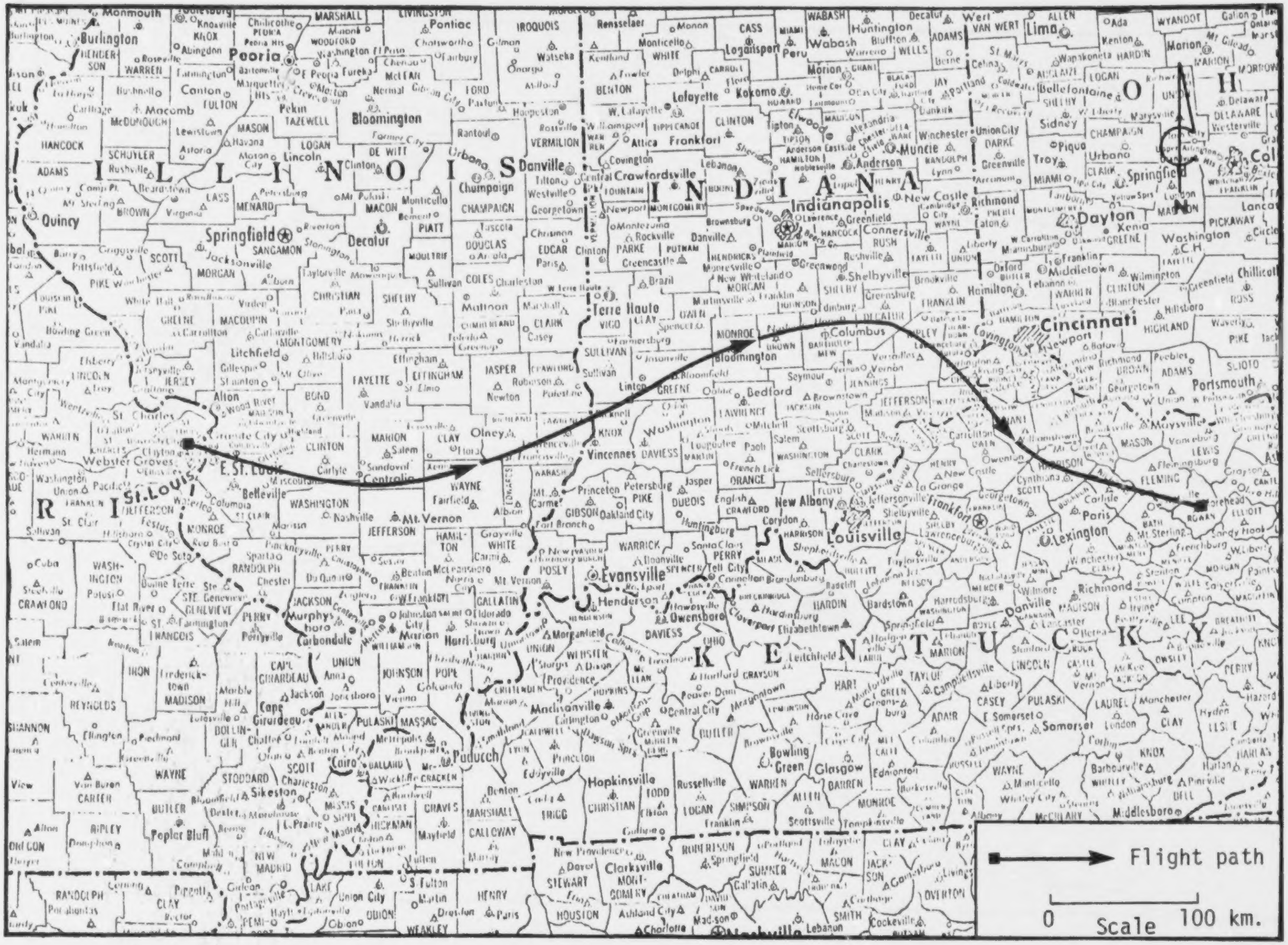

FIGURE 25. APPROXIMATE FLIGHT PATH OF DA VINCI III

Funding

The funds for project DA VINCI and its participants were provided by the Department of Energy, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the National Geographic Society.

Periods of Performance

Two DA VINCI flights originated in the St. Louis area:

DA VINCI II - June 8 and 9, 1976 (340 km traveled)
DA VINCI III - July 23 and 24, 1976 (675 km traveled)

Summary

The DA VINCI balloon, constructed of polyethylene 0.01 centimeters thick and inflated with approximately 4,648 cubic meters of helium, suspended a 2,948 kilogram gondola, a crew of four, over a ton of scientific equipment, and more than 454 kilograms each of batteries and ballast. The balloon flew over the city at the lowest permissible altitude and was transported with the air pollution from St. Louis urban and industrial activities, acting as a Lagragian marker and measurement platform. Measurements were made both in the gondola and from a remote package which was lowered about 60 meters below the gondola. Other aircraft and ground-based experiments were conducted in conjunction with the flights.

Since horizontal and vertical distribution of pollutants downwind of the city are strongly influenced by meteorological conditions, the flight altitude was selected on the basis of pollutant profiles obtained by instrumented aircraft during the flight.

As the mixing layer deepened, the balloon was allowed to rise keeping well within the mixing layer until late afternoon. As atmospheric mixing decayed late in the day, the balloon maintained a fixed altitude and continued to follow the elevated pollutants throughout the night and into the next day. The balloon drifted with the urban/industrial plume as long as data of value could be safely obtained.

In coordination with the DA VINCI flight, an instrumented aircraft mapped cross sections of the urban/industrial plume for the EPA. These data aided in delineating horizontal and vertical diffusion of pollutants in the cross section of the plume containing the balloon, thus greatly facilitating interpretation and modeling of the measurements made on the DA VINCI balloon. The aircraft mapping operations continued throughout the balloon flight.

On the ground, an instrumented van made pollutant concentration measurements under the balloon's path. In addition, a pair of ground-based acoustic sounders were used along the flight path to provide information on the mixing depth of the plume.

Aircraft and ground-based measurements helped to define dilution of the plume by diffusion processes and removal of pollutants at the ground. These determinations were necessary for determining pollution concentration changes by chemical reactions.

On-Board Experiments

The following is a listing of the DA VINCI on-board experiments that measured the properties of fine particles suspended in the air, the gaseous pollutant concentrations, and the meteorological conditions. Particular emphasis was placed on the processes which convert gases to particles and on the characterization of particles formed.

National Oceanic and Atmospheric Administration: R. Pueschel

Instruments were used to filter minute particles from the air. They were analyzed later by electron microscope to determine particle size, shape and composition. Then they were tested to determine their ability to serve as ice nuclei and their ability to scatter light, which would determine the aerosols' effects on incoming sunlight and, therefore, climate.

Lawrence Berkeley Laboratory: T. Novakov, C. Hollowell, R. Giaque and S. Chang

Two different types of filter samples were taken. One was analyzed via electron spectroscopy for chemical analyses (ESCA) for data on the chemical state of sulfur, nitrogen and carbon present. These samples were analyzed for characteristic functional groups using attentuated total reflectance infrared spectroscopy. The second type of sample was used for x-ray fluorescence analysis, principally for sulfur, aluminum, silicon, lead and bromine.

Lawrence Livermore Laboratory: R. Ragini

After elemental analysis (x-ray flourescence) of the above filters by LBL, they were subjected to neutron activation analysis to obtain further elemental composition information.

Los Alamos Scientific Laboratory: W. Sedlacek

A quartz-microbalance cascade impactor was flown to determine the change in particle size distribution as gas to particle conversion progressed.

Sandia Laboratories: B. Zak and R. Schellenbaum

Measurements of the intensity and spectral distribution of radiation were obtained. A spectrometer defined the ultraviolet and visible solar flux that causes the photochemistry proceeding within the plume. A pulsed fluorescent detector was also used to gather sulfur dioxide concentration data for studying the conversion of sulfur dioxide to sulfate. An ozone monitor gathered data on long-distance transport of ozone aloft, particularly at night.

Sandia Laboratories: R. Woods, and Washington State University: R. Rasmussen

Grab samples taken with passivated and conditioned stainless steel flasks were analyzed for carbon monoxide, nitrous oxide, light hydrocarbons and halocarbons. Since the Freons do not participate in the chemical processes occurring within the plume, they were able to serve as inert tracers.

Research Triangle Institute: J. Worth and J. Tommerdahl

Grab samples were taken, principally for light hydrocarbons. Hydrocarbons of interest were the reactive species which participate in the atmospheric chemistry. This experiment was aimed at the behavior of ozone precursers through the nocturnal cycle in a well-aged, elevated plume.

Atmospheric Sciences Laboratory: H. Gallard, and University of Texas at El Paso: M. Izquierdo

Temperature, pressure, water vapor and ozone measurements were made. Water vapor measurements are important in assessing the role of liquid phase oxidation of sulfur dioxide. Ozone measurements were made both from the gondola and from the "down package" about 60 meters below the gondola.

National Oceanic and Atmospheric Administration: J. Angell, W. Hoecker

Sets of three tetroons -- tetrahedral balloons roughly five feet in diameter -- were released from the balloon. The flight crew tracked these balloons as air currents separated them and carried them off in different directions. The paths of the tetroons and the time it took them to disperse provided information on atmospheric diffusion processes.

AeroVironment Incorporated: P. McCready

Data on the eddy diffusivity of the atmosphere in the vicinity of the balloon were obtained by using an instrument suspended from the "down package." A three-axis anemometer also continuously recorded the relative velocity of the air at the gondola throughout the flight.

National Oceanic and Atmospheric Administration: P. Kuhn

An infrared radiometer was used to study the radiative properties of aerosols in the St. Louis pollutant plume and of the land surfaces beneath the balloon. The study was focused on the heat balance of the atmosphere, rather than directly upon atmospheric chemistry. It provided insight into the relationships of aerosol character, atmospheric mixing and turbulence with properties of the earth's surface and incoming radiation from the sun.

Brookhaven National Laboratory: L. Newman, R. Tanner, R. Garber, J. Forrest and D. Leahy

Treated filters were employed to measure the concentrations of sulfur dioxide, ammonia, nitrates, and sulfates.

Coordinated Experiments

Washington University: R. Husar

Plume mapping was accomplished with an instrumented airplane for the EPA's Midwest Interstate Sulfur Transport and Transformation (MISTT) program. The plane flew in patterns to define the cross section of the plume. Measurements were made of sulfur dioxide, ozone, nitric oxide, nitrogen dioxide, particulate sulfur, temperature, dew point, eddy diffusivity, condensation nuclei and particulate size distribution. Sulfur dioxide and particulate forms of sulfur were of the most interest. The objective was to determine the transport, transformation and removal processes involving sulfur compounds by accounting for total sulfur mass flow. The plane used the balloon as a Lagrangian marker for a particular parcel of air so that successive cross-sectional flights could refer to the same air parcel.

Research Triangle Institute: J. Worth, J. Tommerdahl

In addition to grab samples taken on the gondola, measurements were made from an instrumented van following the balloon on the ground. During the flight, the van measured ground level concentrations of ozone, oxidant, nitric oxide, nitrogen dioxide, total sulfur, total hydrocarbons, non-methane hydrocarbons, selected reactive hydrocarbons, and carbon monoxide. The van also carried a full complement of calibration instrumentation which was used to calibrate the balloon-borne instrumentation before and immediately after each flight.

Argonne National Laboratory: E. Miller

Measurements of the inversion level and of atmospheric turbulence near the balloon were made by "leap-frogging" mobile acoustic sounders along its path to provide information on the mixing depth of the plume. The rate at which chemistry proceeds in the atmosphere is strongly dependent upon reactant concentrations. These, in turn, are determined not only by source strength, but also by the degree of the mixing of polluted with relatively clean air. The acoustic sounder data provided information on the dilution processes occurring in the vicinity of the balloon.

Location of Information Concerning Data Collection

Additional information concerning Project DA VINCI may be obtained by contacting:

Bernard D. Zak
Sandia Laboratories
Division 5333
Box 5800
Albuquerque, NM 87112

(505) 264-7328

Publications

Zak, B. D. Project DA VINCI: An Overview. Sandia Laboratories, Albuquerque, New Mexico. October 1976.

Zak, B. D. Project DA VINCI: A Status Report. Sandia Laboratories, Albuquerque, New Mexico. March 1976.

Zak, B. D. et al. Project DA VINCI: A Study of Long Range Air Pollution Using a Balloon-Borne Lagrangian Measurement Platform, Volumes I - IV. Sandia Laboratories, Albuquerque, New Mexico. SAND 78-0403. In preparation.

12.4 MISCELLANEOUS INVESTIGATIONS

12.4.1 DIRECTIONAL HI-VOL SAMPLING AT GRANITE CITY STEEL

Principal Investigators	Project Officer
Kenneth E. Pickering GEOMET, Incorporated 15 Firstfield Road Gaithersburg, MD 20760 (301) 948-0755	Mark Antell Environmental Protection Agency Office of Enforcement 401 M Street, SW Washington, DC 20460 (202) 755-8137

Ronald G. Draftz
IIT Research Institute
Fine Particle Research Section
10 West 35th Street
Chicago, IL 60616
(312) 567-4291

Funding EPA Contract No. 68-01-4144, Task No. 1

Period of Performance January 1976 - March 1977

Technical Approach

This ambient monitoring study was conducted to determine the impact of coking on total suspended particulate concentrations and, if possible, the impact from specified coking operations, namely charging, pushing and quenching.

The site selected for this study was the Granite City Steel Company Coke Works in Granite City, Illinois. Two sampling sites selected 1200 m north and south of the coke ovens were equipped with standard hi-vol filter samplers and hi-vol impactor samplers. The theory behind the site location was that with persistent southerly winds, the south sampler served as a baseline monitor and the northern site indicated the pollutant contribution of the coking facility. The opposite being true with a northerly wind.

Filter samples collected on days with high wind persistence were analyzed by a variety of analytical methods to determine coking impact.

Periods of Data Collection

One hi-vol and one cascade impactor at each site were operated in tandem. Each pair was activated once every three days from 0000-2400 CST on an alternating schedule. To determine which samples contain particulates derived from the coking facility, wind data from RAMS Site 103 were compared to the sampling dates. Using a wind persistence formula and determing the predominant wind direction for the day, a decision was made whether or not to subject the sample to laboratory analysis.

Analyzed sample dates, with the necessary wind persistence, were:

March 2, 1976
June 13, 1976
September 16, 1976
February 10 and 22, 1976

Parameters Measured	Instrument/Method Used
Total suspended particulate mass, total cyclohexane soluble organics, Benzo (a) pyrene concentration, free carbon content, lead and vanadium concentrations	The collection process utilized a Sierra standard hi-vol sampler with type A glass filter. A constant air flow was maintained by a Model 310, Sierra Instruments, Constant Flow Controller. Flow rate was checked and adjusted every three days. In addition, two Sierra Model 235 High Volume Cascade impactors were operated at each site. Flow adjustments were identical to that of the hi-vols. a) Total cyclohexane soluble organics by soxhlet extraction. b) Benzo (a) pyrene concentration by

Parameters Measured	Instrument/Method Used (continued)
	high pressure liquid chromatography. c) Free carbon content by low temperature plasma ashing. d) Elemental analysis for lead and vanadium to correct for free carbon content due to auto exhaust and oil soot.
Identification of charge, push and quench aerosols	Optical and electron microscopy.
Wind speed and direction	Meteorology Research Inc. Model 1022 wind system oriented to true north. Located at RAMS Site 103 mounted 30 m above ground level.

Calibration and Quality Control Procedures

Meteorological Research Inc. Model 1022 wind system.	The wind direction and speed were calibrated every six months, speed by using a constant RPM motor and direction by sighting the directional vane on a nearby target whose bearing from the station had been accurately determined.
Sierra Hi-Vols	Prior to the study, the hi-vols were calibrated twice by both the U.S. EPA and the Illinois EPA.

Location of Information Concerning Data Acquisition

James Henry
Granite City Air Pollution Control Office
2301 Adams Street
Granite City, IL 62040
(618) 451-7636

Location and Type of Data Available

Data in report format are publicly not available at this time. For further information contact the Project Officer.

Publications

Draftz, R. G., K. E. Pickering, and D. J. Mosechandreas. Analysis of Total Suspended Particulates Collected at Granite City, Illinois - TSP Impact From Coke Batteries. GEOMET, Incorporated, Gaithersburgh, Maryland. Task No. 1 Final Report, Contract 68-01-4144. December 1977.

12.4.2 HI-VOL STUDY AT CITY SITE 2 AND MUNICIPAL COURT BUILDING

Principal Investigators	Project Officer
Kenneth A. Hardy Florida International University Department of Physical Sciences Tamiami Trail Miami, FL 33199 (305) 552-2605	Ronald K. Patterson (MD-57) Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-2254
Ronald G. Draftz IIT Research Institute Fine Particle Research Section 10 West 35th Street Chicago, IL 60616 (312) 567-4291	

Funding EPA Grant No. R803078

Period of Performance July 1975

Technical Approach

The objective of this study was to determine aerosol sources based on elemental concentrations collected from distinct wind directions.

Four Battelle wind activated directional impactors and one standard Battelle impactor were located at both the City Site 2 at Broadway and Hurck, and the Municipal Court Building at 14th and Market. In addition to these instruments, two General Metals hi-vol samplers operated as part of the City of St. Louis Pollution Control Network and a Jenson-Nelson streaker were situated at each site.

Periods of Data Collection

The Jenson-Nelson streakers operated continually throughout the period of the experiment. An active sampling period of 24 hours per directional impactor was attempted. This represented 24 hours of coverage for each wind directional quadrant. The Battelle standard impactor operated from 0000-2400 CST throughout the duration of the experiment. The two hi-vols supplied by the City of St. Louis operated on an alternate basis from 0000-2400 CST throughout the experimental period of July 15-31, 1975.

Parameters Measured	Instrument/Method Used
Sixteen elements were identified and analyzed with two hour time resolution (Aluminum, Silicon, Sulfur, Chlorine, Potassium, Calcium, Titanium, Vanadium, Chromium, Manganese, Iron, Nickel, Copper, Zinc, Bromine, Lead)	Jenson-Nelson streaker using 6" x 1" Nuclepore filter paper with two hour resolution. The samples were analyzed by the Proton Induced X-Ray Emission (PIXE) method at Florida State University. Flow rate was checked every 24 hours.
Sixteen elements fractionated and segregated by wind direction. (Aluminum, Silicon, Sulfur, Chlorine, Potassium, Calcium, Titanium, Vanadium, Chromium, Manganese, Iron, Nickel, Copper, Zinc, Bromine, Lead)	Four Battelle wind activated impactors at each site. Each impactor's sampling range encompassed approximately 90° of azimuth with respect to magnetic north. Samples were analyzed using the PIXE method by Florida State University. Flow rate was recorded before and after each sampling period to determine if any drift had occurred.
Sixteen elements fractionated by size and analyzed. (Same elements as above)	Battelle standard impactor differentiating particle size. The samples were analyzed using the PIXE method by Florida State University. Flow rate was recorded before and after each sampling period to determine if any drift had occurred.

Parameters Measured	Instrument/Method Used (continued)
Total suspended particulate mass for 24 hour period.	General Metals hi-vol supplied by the City of St. Louis with microscopical analysis by IIT Research Institute. Flow rate was recorded when the clean filter was installed and when the exposed filter was removed. Flow rate during a sampling interval is the average of these readings.

Calibration and Quality Control Procedures

Jenson-Nelson Streaker	The streaker operated in tandem with the Battelle standard impactor utilizing the same vacuum pump. The desired impactor flow rate was produced in the laboratory utilizing a rotameter.
Battelle Wind Activated and Standard Impactors	The desired impactor flow rates were produced in the laboratory utilizing a rotameter.
City of St. Louis General Metals Hi-Vol	The flowmeters were calibrated immediately prior to the study using a calibrated orifice plate and manometer.

Location and Type of Data Available

Data will be available in report format from both institutions where the particulate analyses were performed pending additional funding by EPA.

For all Jenson-Nelson streaker data and the Proton Induced X-Ray Emission analysis contact Kenneth A. Hardy, Principal Investigator. For impactor data analyzed for particulate type and source contact Ronald G. Draftz, Principal Investigator.

Publication

A final report on this study is expected to be published in Septmeber 1979.

12.4.3 ION CHROMATOGRAPH ANALYSIS OF RAPS HI-VOL FILTERS

Principal Investigators	Project Officer
Edward Nelson Rockwell International Air Monitoring Center 11640 Administration Drive St. Louis, MO 63141 (314) 567-6722	Ronald K. Patterson Environmental Protection Agency Environmental Sciences Research Laboratory Research Triangle Park, NC 27711 (919) 541-2254

Joan Lathouse
Battelle-Columbus Laboratories
505 King Avenue
Columbus, OH 43201

(614) 424-5237

Funding EPA Contract No. 68-02-2093, Task Order No. 101 (Sample Collection by Rockwell International)

EPA Contract No. 68-02-2454 (Laboratory Analysis by Battelle-Columbus)

Period of Performance August - September 1976

Technical Approach

This study was intended to investigate the importance of nitrite in the ambient atmosphere.

Hi-vols located at ten separate RAMS sites were operational during the study period. The spatial relationship and numerical designation of the sites are annotated in Figure 26.

All instruments were located on platforms extending from the roofs of

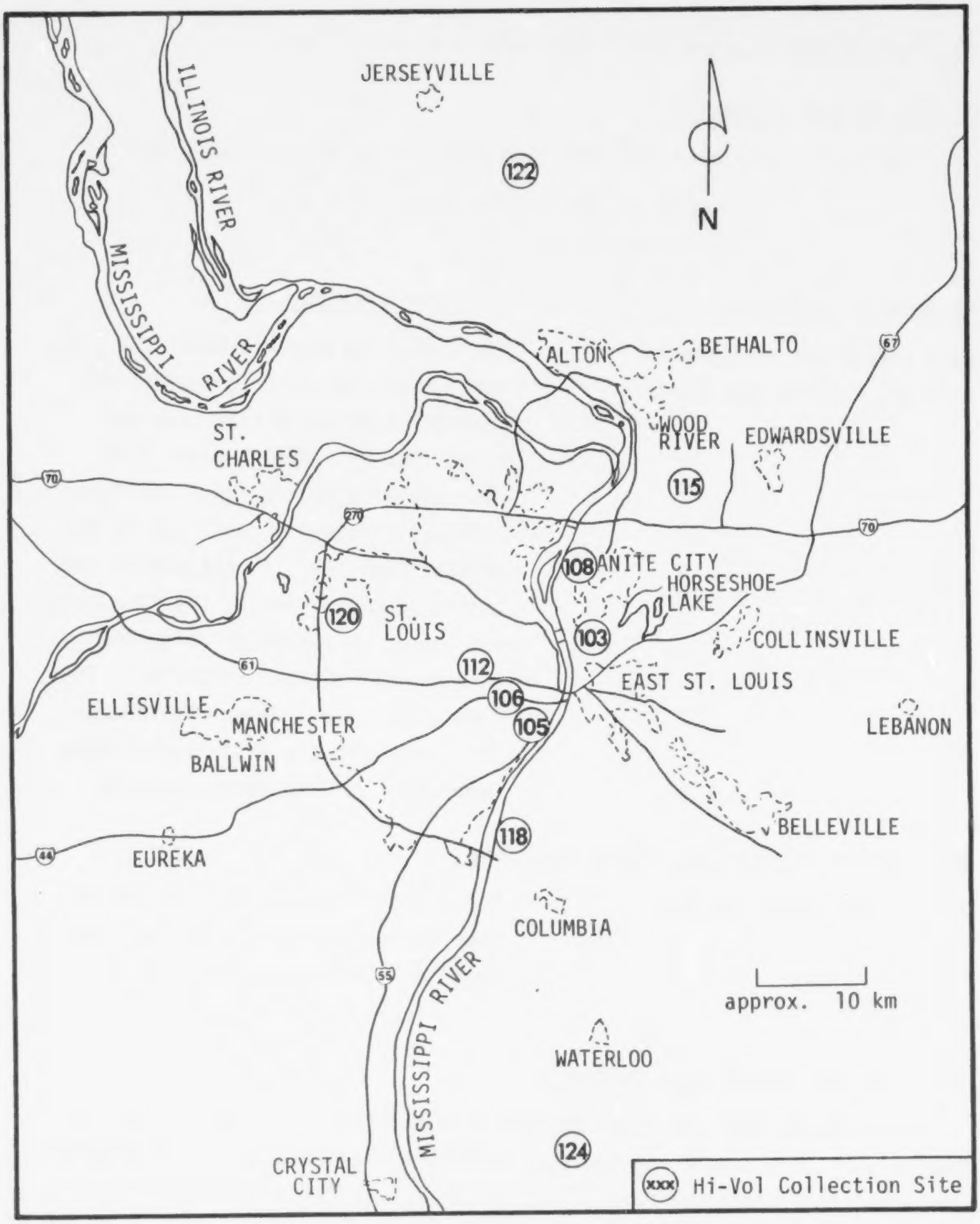

FIGURE 26. COLLECTION SITES FOR THE 1976 HI-VOL STUDY.

the RAMS shelters approximately four meters above surface.

Periods of Data Collection

The ten hi-vols operated from 0000-2400 CST on the following days:

August 25, 28, and 31, 1976
September 3, 1976

Parameters Measured	Instrument/Method Used
Each sample was analyzed for nitrite, sulfate and nitrate	The Sierra Instruments Model 305 standard hi-vol was used to collect the sample. A constant flow rate was maintained by a Sierra Model 310B Constant Flow Controller. The flow rate was constantly monitored by the on-site computer. At the end of the active sampling period, the flow rate was manually checked by using the RAMS station digital voltmeter. The sample was then treated with NH_3 and transferred to the Battelle-Columbus Laboratory for ion chromatography.

Calibration and Quality Control Procedures

Sierra Instruments Hi-Vol	The hi-vol flow rate was calibrated once every three months using a Top-Loading High Volume Orifice Calibrator, Sierra Model 330.

Location and Type of Data Available

At present only the first run analysis has been performed. A re-run analysis of each sample is pending. Additional information may be obtained from the EPA Project Officer.

12.4.4 DEPARTMENT OF TRANSPORTATION HIGHWAY EMISSIONS STUDY

Principal Investigator

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U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, MA 02142
(617) 494-2185

Funding Department of Transportation

Period of Performance July 1975

Summary

The formal title of this study was "The Department of Transportation Prototype Gas Correlation Spectrometer Integrated Path Carbon Monoxide Burden Measurements".

This prototype experiment was conducted to determine the feasibility of integrated path sensing of low concentrations of CO utilizing a Science Applications gas correlation spectrometer. The field measurements were performed in St. Louis during the period of July 10 to 28, 1975 at U.S. Highway 40 near 21st Street. Two 20 foot towers were erected on either side of Highway 40, 120 feet apart. One tower supported the correlation spectrometer and infrared source at elevations of 7, 13 and 20 feet. The other tower supported a retroreflector at corresponding elevations. Carbon monoxide burden, atmospheric temperature, humidity and wind speed were monitored at each elevation. Traffic volume was monitored and recorded on punched tape by the Missouri Highway Commission. During selected peak traffic conditions, EPA personnel took bag samples for carbon monoxide analysis at 3, 9, 37, and 73 meters upwind and downwind of the correlation spectrometer sampling site. This facilitated CO burden comparisons and provided calibration criteria for a pending DOT/General Motors study in Melford, Michigan.

Based on experience gained during this field experiment, the towers in the Michigan study will be replaced by mobile, height-adjustable platforms and the gas analyzer system is being modified for easier installation and optical alignment and for expanded measurement span.

No data are available due to the prototype nature of this experiment.

Details of the sampling procedures may be obtained from the DOT Principal Investigator.

Publication

None

12.4.5 BIOLOGICAL INDICATORS OF POLLUTION

Principal Investigators

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Charles R. Granger
Donald E. Grogan
Buford R. Holt
John E. Ridgway
University of Missouri - St. Louis
Department of Biology
St. Louis, MO 63135
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Marion Bakula
Dorothy Feir
Stephen J. Dina
John G. Severson, Jr.
St. Louis University
Department of Biology
3507 Laclede Ave.
St. Louis, MO 63103
(314) 535-3300

Project Officer

Lawrence Ranier
Environmental Protection Agency
Corvallis Environmental Research Laboratory
200 Southwest 35th Street
Corvallis, OR 97330
(503) 757-4625

Funding EPA Grant No. R802678

Period of Performance December 1973 - July 1974

Introduction

The objective of this study was to propose a series of biological indicators of pollution. The reports which follow consist of state-of-the-art literature reviews and reports of pilot studies for proposed measures of air pollution impact based on remote sensing, demographic, genetic, morphological, physiological, and biochemical aspects of air pollution. All studies in this report were performed in 1974.

The Protocol developed consists of nine independent studies. The studies and their investigators follow.

The Effects of Air Pollution on Polyploidy in Plants	John E. Averett
Cellular and Genetic Effects of Atmospheric Pollution on Animals	Marion Bakula
Assessing the Effects of Air Pollution on Vegetation Using Remote Sensing	Charles R. Granger
The Effect of Air Pollutants on the Physiology and Biochemistry of Vertebrate Systems	Donald E. Grogan
Demographic Measures of Air Pollution Impacts on Plant Populations	Buford R. Holt
The Interactions of Invertebrates and Air Pollutants	Dorothy Feir
Literature Review of the Effects of Air Pollution to the Phytocomponents of the Ecosystem	John E. Ridgway
Effects of Airborne Pollutants on Physiological, Ecological, and Biochemical Processes of Plants	John G. Severson and Stephen J. Dina
Preliminary Analysis of the Effects of Atmospheric Pollution on Annual Ring-Widths of the Sycamore in the St. Louis Area	John E. Ridgway, Eugene Estes, Buford R. Holt

Summary

The Effects of Air Pollution on Polyploidy in Plants

The abstract suggests that the ratio of polyploids to diploids of specific plant species may serve as a potential pollution indicator. The theory is that the number of polyploids increase as environmental demands become more severe due to their greater adaptability.

Dr. Averett outlines procedures for implementing a project to determine pollution levels by monitoring relative numbers of diploid and polyploids of indicator species. Included in the body of the report is an inventory of species and chromosome numbers of weedy plants in the St. Louis area which might be used for pollution monitoring.

Cellular and Genetic Effects of Atmospheric Pollution on Animals

The first phase of this review was concerned with describing cellular and genetic changes accompanying animal exposure to monitored air pollutants. Sulfur dioxide, ozone, nitrogen oxides, polycyclic hydrocarbons and carbon monoxide are individually reviewed; combinations of pollutants and particulates are included within relevant sections. Cellular changes discussed in the review are alterations occurring in different cell types, plasma membranes, organelles, enzymes and other organic molecules. The majority of the studies involve laboratory animals and not those species indigenous to an urban environment.

The second phase of this study involved a field experiment utilizing four laboratory stocks of D. melanogaster (fruit flys). Two wild type stocks, one inbred and two mutant stocks, ebony and tumor-brown, were maintained at three outdoor sites, representing various pollutant concentrations, and one indoor control site for two generations. (Figure 27). First and second generation adult flies were counted, weighed and examined for their relative abilities to produce adult offspring and their response to sodium chloride stress. This is to obtain genetic and physiological estimates of air pollution effects on animals, and to find what role the genotype plays in the response of animals to air pollution. An important aspect of the

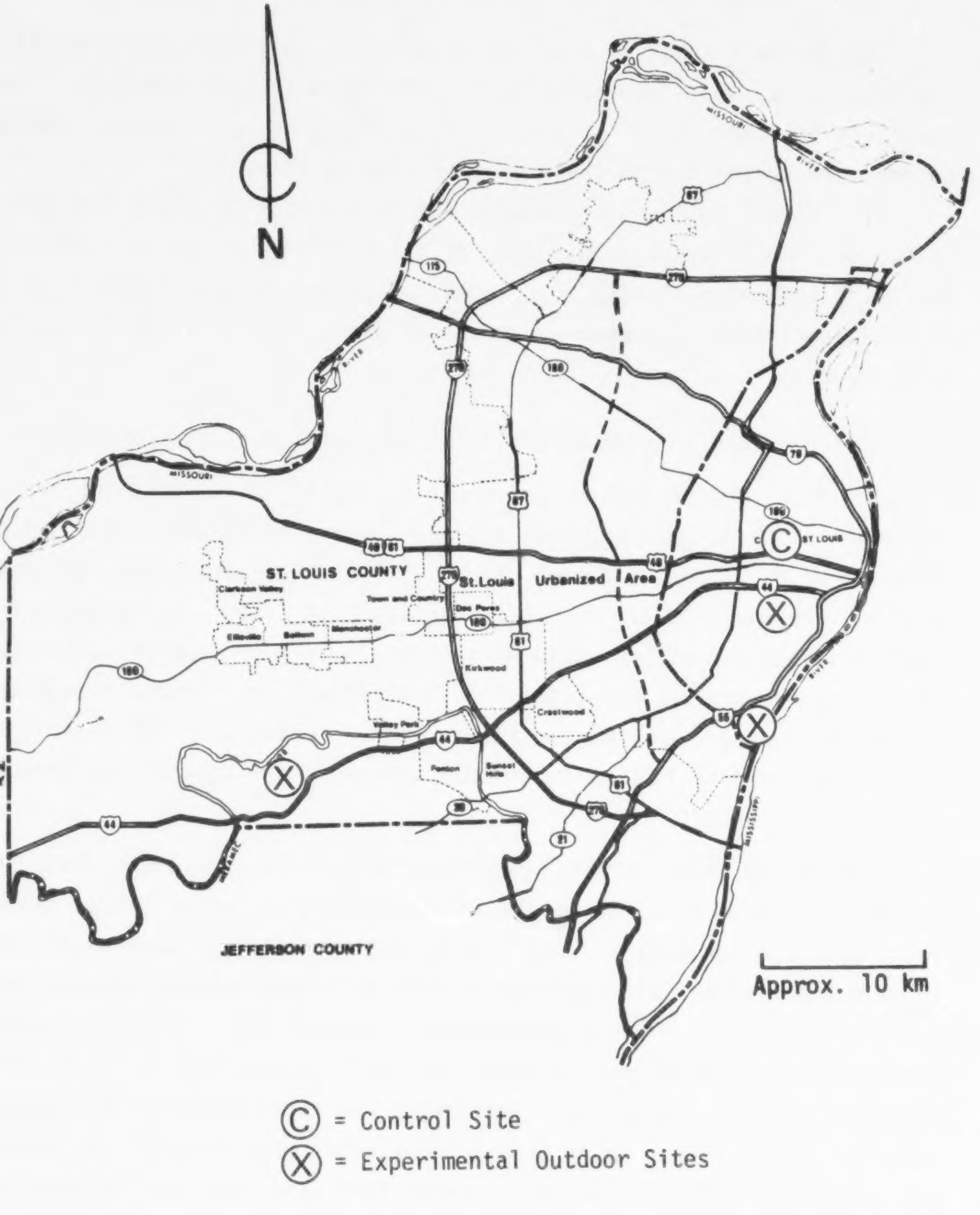

FIGURE 27. FRUIT FLY OUTDOOR SITES

research was to contrast the responses of homozygous and hetrozygous populations to see whether the greater genetic variability of three of the stocks would result in more rapid adaptation to an adverse environment.

Assessing the Effects of Air Pollution on Vegetation Using Remote Sensing

This study explored the basic techniques and feasibility of remote sensing as an air pollution effects monitoring system for vegetation in the St. Louis area. Goals and objectives of this effort included the following:

1. To review the literature on remote sensing systems with respect to their use in detecting both visible and invisible air pollution injury to vegetation.
2. To relate specifications for the method of appropriate remote sensing techniques that will yield indices which are important biological indicators of air pollution effects.
3. To examine the feasibility of remote sensing for the economic assessment of damage of air pollution in the St. Louis area.
4. To predict the reliability of remote sensing for vegetative assessment when used for proposed biological studies in the St. Louis Metropolitan Area.
5. To correlate the degree of complimentarity of remote sensing to the on-going RAPS and METROMEX Programs.
6. To document the use of a remote sensing system as a factor in the development of a model for air pollution effects.
7. To point out the use of remote sensing systems in the assessment of general trends in environmental degradation in and surrounding large metropolitan areas.
8. To illustrate the usefulness of remote sensing in pollution control strategies and general regulatory programs.

The Effect of Air Pollutants on the Physiology and Biochemistry of Vertebrate Systems

This report was a literary search which summarized the findings of numerous investigators indicating the effects air pollutants have on vertebrate systems. The pollutants studied were carbon monoxide, nitrogen dioxide, nitrous dioxide, sulfur dioxide, carbon disulfide, hydrogen sulfide, ozone and lead. The sources consulted for this study were supplied by the EPA computer service and Biological Abstracts.

In anticipation of amplified responses to air pollution stresses by strong biological interaction with pollution resistant species, tests were based on interspecific competition and grazing tolerance.

Demographic Measures of Air Pollution Impacts on Plant Populations

In this paper, ten demographically based measures of air pollution impact were proposed for plant populations and ranked according to their potential for development into relatively simple bioassays. Tests based on interspecific competition and grazing tolerance were recommended in anticipation of amplified responses to air pollution. The amplified responses were attributed to strong biological interaction with pollution resistant species. Winter wheat and soybeans were recommended as test organisms for the St. Louis region on the basis of manipulation.

The Interactions of Invertebrates and Air Pollutants

This study was undertaken in view of the large numbers of invertebrates, their significance to man and the lack of information in this area. The major objectives of the study were: to do a thorough literature search to determine what is known about the effects of air pollutants on invertebrates and the effects of invertebrates on the pollutant concentrations; to determine from the literature the indirect effects of air pollution on populations of insects which are herbivorous; and to perform a small pilot field study to determine the feasibility of a meaningful biological monitoring system of air pollutants by invertebrates. The conclusions from these objectives were used to outline the type of work needed in this aspect for meaningful air pollution studies.

Literature Review of the Effects of Air Pollution to the Phytocomponents of the Ecosystem

The abstract reviews the effects of air pollution on both seed and nonseed plants. The report delineates the influence of air pollution upon vegetation at the morphological, physiological and enzymological levels as reported in the literature during the last decade. The literature has been researched from the Environmental Protection Agency Abstract Service, Biological Abstracts, Biosearch Index, Pollution Abstracts, and Biological Indicators of Environmental Pollution.

Effects of Airborne Pollutants on Physiological, Ecological, and Biochemical Processes of Plants

This review presents recent information on the effects of airborne pollutants on the physiological, ecological and biochemical processes of higher plants. It is divided into six sections to correlate with the major airborne pollutants being monitored in the Greater St. Louis Area, namely, sulfur oxides, nitrogen oxides, oxidants, hydrocarbons, carbon monoxide and particulates.

Preliminary Analysis of the Effects of Atmospheric Pollution on Annual Ring-Widths of the Sycamore (Platonus Occidentalis L.) in the St. Louis Area

The report describes a preliminary examination of the annual ring-widths of the mature sycamore. The study was made to determine what effects atmospheric pollution might have upon the width of the annual ring. Trees from three sites, each representing different levels of atmospheric pollution, were sampled by taking two cores from each tree. The cores were 180° apart and taken by standard dendro-chronological techniques. The sycamore was selected for this study because it was the only apparent species of any age that was surviving in the more heavily polluted areas. The area chosen to represent an area of high pollutant concentration was Carondelet

Park in South County. The moderate pollution site was Forest Park and the light pollution area chosen was in Weldon Springs in St. Charles County.

The relative size of the annual rings for the representative trees of each site were compared. Preliminary findings indicated that the tree ring size of the south St. Louis site (heavy pollution) were statistically smaller than the trees from the other locations. Further findings and suggestions are included in the text of the report.

Publication

Averett, J. E., M. Bakula, C. R. Granger, D. E. Grogan, B. R. Holt, D. Feir, J. E. Ridgway, J. G. Severson, Jr., and S. J. Dina. Protocol For a Biological (Ecological) Effects Monitoring System. University of Missouri-St. Louis and St. Louis University, St. Louis, Missouri. Final Report, EPA Grant No. R802678. October 1974.

12.4.6 FATE OF ATMOSPHERIC POLLUTANTS STUDY (FAPS)

Principal Investigator

James P. Lodge (formerly with)
National Center for Atmospheric Research
Laboratory of Atmospheric Sciences
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Boulder, CO 80307

(303) 494-5151

Funding National Science Foundation

Periods of Performance October 1971, October 1972, and April 1973

Summary

The Fate of Atmospheric Pollutants Study (FAPS) was conducted by the National Center for Atmospheric Research (NCAR), which is sponsored by the National Science Foundation.

The overall purpose of the FAPS measurements was to assess the effect of urban pollution on the global atmosphere. More specifically, the purpose of FAPS was to obtain estimates of the mean lifetimes of a number of short-lived pollutants emitted from a major city (St. Louis). In fulfilling the objectives, measurements were made in three dimensions in the pollutant plume.

The field tests of October 1972 and April 1973 included both ground and air measurements on arcs of 80- and 120- km radius around St. Louis. See Figure 28. Although these field tests were designed to be preliminary experiments, this program was terminated sooner than originally planned. Thus, available data is fragmentary since the preliminary field tests became in fact the final study only after they were completed.

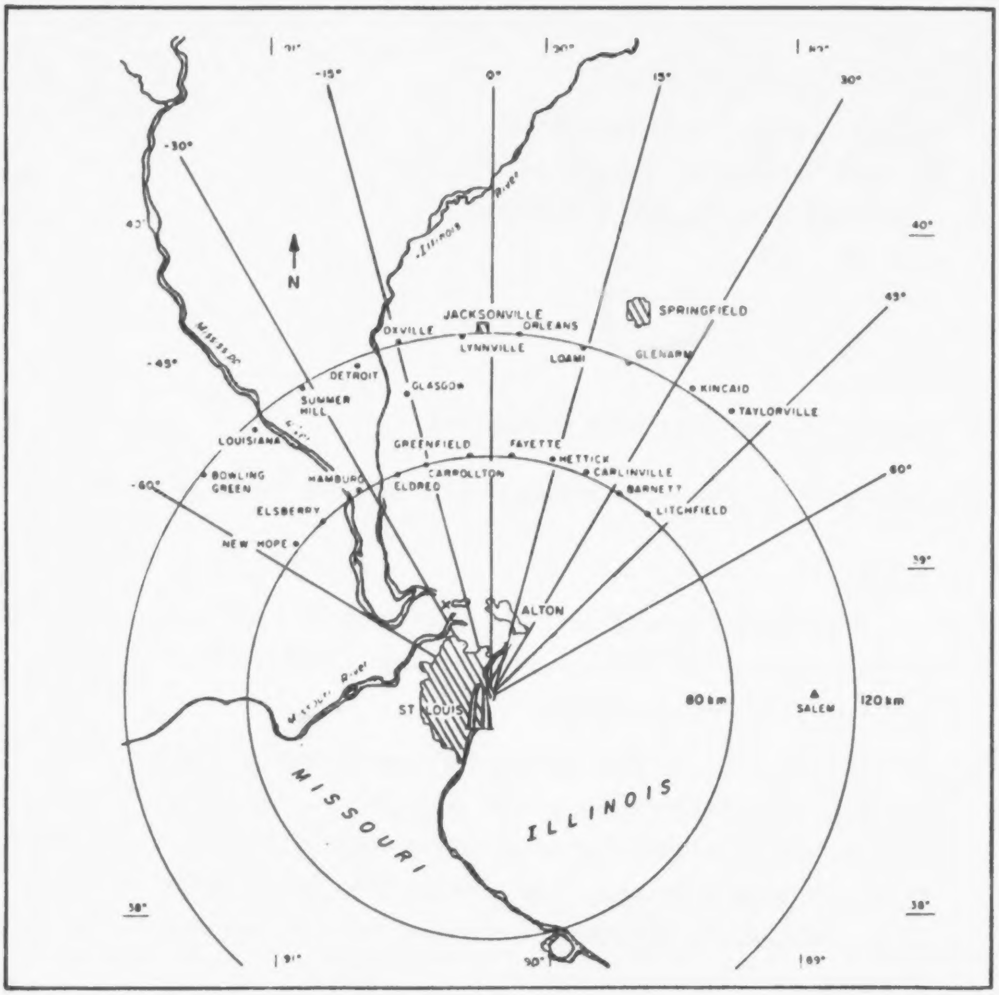

FIGURE 28. MAP OF THE ST. LOUIS AREA SHOWING THE 80-km AND 120-km ARCS AND THE SITE LOCATIONS.

Pollutant measurements were made in conjunction with meteorological observations of the movement of air masses over and around St. Louis to give precise location of the pollution plume.

In addition, background trace gas concentrations were determined in the rural areas for comparison purposes, and two models were used to forecast the behavior of the plume.

The FAPS scientists utilized the chemistry laboratory at MacMurray College, Jacksonville, Illinois, to perform some analyses and set up their chemical equipment.

On the ground, scientists measured the downwind concentrations of pollutants such as sulfur dioxide, hydrogen sulfide, oxides of nitrogen, hydrocarbons and particulate matter. Simultaneously, similar measurements were made from aircraft to locate pollution layers aloft.

Two aircraft were used in both field tests. The NCAR Queen Air was equipped to take bubbler and bag samples and was equipped with a condensation nuclei counter. In April 1973, a nephelometer and an oxidant monitor were added. The primary mission of the Queen Air was to fly back and forth within the plume to measure concentrations aloft in the plume. The other plane, a Bonanza, had the location and delineation of the plume as its primary mission. The Bonanza was equipped with a light-scattering instrument which measured the number of particles in 2 adjacent size ranges. Both aircraft had temperature, dew point temperature, and pressure recorders.

Location and Type of Data Available

Additional information on data collection and availability may be obtained from the NCAR Principal Investigator.

Publication

Lodge, J. P. Results of the FAPS Field Experiment in the St. Louis Area. National Center for Atmospheric Research, Boulder, Colorado. March 1971, May 1973, and June 1974.

12.4.7 OPTIMUM URBAN SAMPLING NETWORK SELECTION

Principal Investigator	Project Officers
Fred M. Vukovich Research Triangle Institute Research Triangle Park, NC 27709 (919) 541-5813	James L. McElroy Environmental Protection Agency Environmental Monitoring and Support Laboratory Las Vegas, NV 89114 (702) 736-2969 Ext. 241
	Richard Dirks National Science Foundation Washington, DC 20550 (202) 632-4380

Funding Phase I NSF Grant No. GI-34345
Phase II NSF Grant No. AEN 72-03431 A03
EPA Contract No. 68-03-2187

Periods of Performance (in St. Louis) July - August 1975
February - March 1976

Technical Approach

The first phase of this investigation initiated in 1972, concerned the development of the theory and the models to establish an optimum meteorological and air pollution sampling network in urban areas. The theory and models are generalized to be applicable to any urban area.

The optimum network provides a basis whereby the distribution of any given pollutant may be obtained at a given time over the domain of the network. The data may be used to determine long-term statistics or short-term analysis.

Three specific models are required to determine the optimum network and acquire the air pollution distribution over the domain of the network. These are: a three-dimensional hydrodynamic model; a statistical model; and an objective variational analysis model.

The basis of the network is the wind field in the urban area rather than the air pollution distribution.

Phase II of this research project concerned itself with verifying and testing the models generated in Phase I. St. Louis was chosen as the test site particularly because the RAPS would provide corollary data to evaluate the optimum network.

During the summer of 1975 and the winter of 1976, field programs were conducted concurrent with a RAPS intensive study period to collect data to test and evaluate the optimum network.

The optimum network consisted of nineteen stations, sixteen, of which, coincided or nearly coincided with existing RAPS or city/county stations.

It was necessary for Research Triangle Institute (RTI) to establish i's own stations at three locations. These sampling stations were located on the grounds of Incarnate Word Academy in northwest St. Louis County; on the grounds of Kenrick Seminary in southwest St. Louis County; and on the grounds of the East Side Sanitary District's South Pumping Station in East St. Louis, Illinois. Figure 29 shows the locations of all nineteen stations.

The facility on the grounds of Incarnate Word Academy consisted of the RTI Mobile Ambient Air Monitoring Laboratory. The facility contains a 10-m crank-up tower for the wind system. The van was located at the southwest end of the Academy's baseball field.

The facilities at both the South Pumping Station and on the grounds of Kenrick Seminary consisted of a metal shelter and a 10-m tower for the wind system. Each shelter contained a Beckman 6800 and strip chart recorders.

The Kenrick facility was approximately 100 m southwest of the Seminary complex. The South Pumping Station was located in the rural portion of Cahokia, Illinois and its RTI housing was about 100 m southeast of the pumping station.

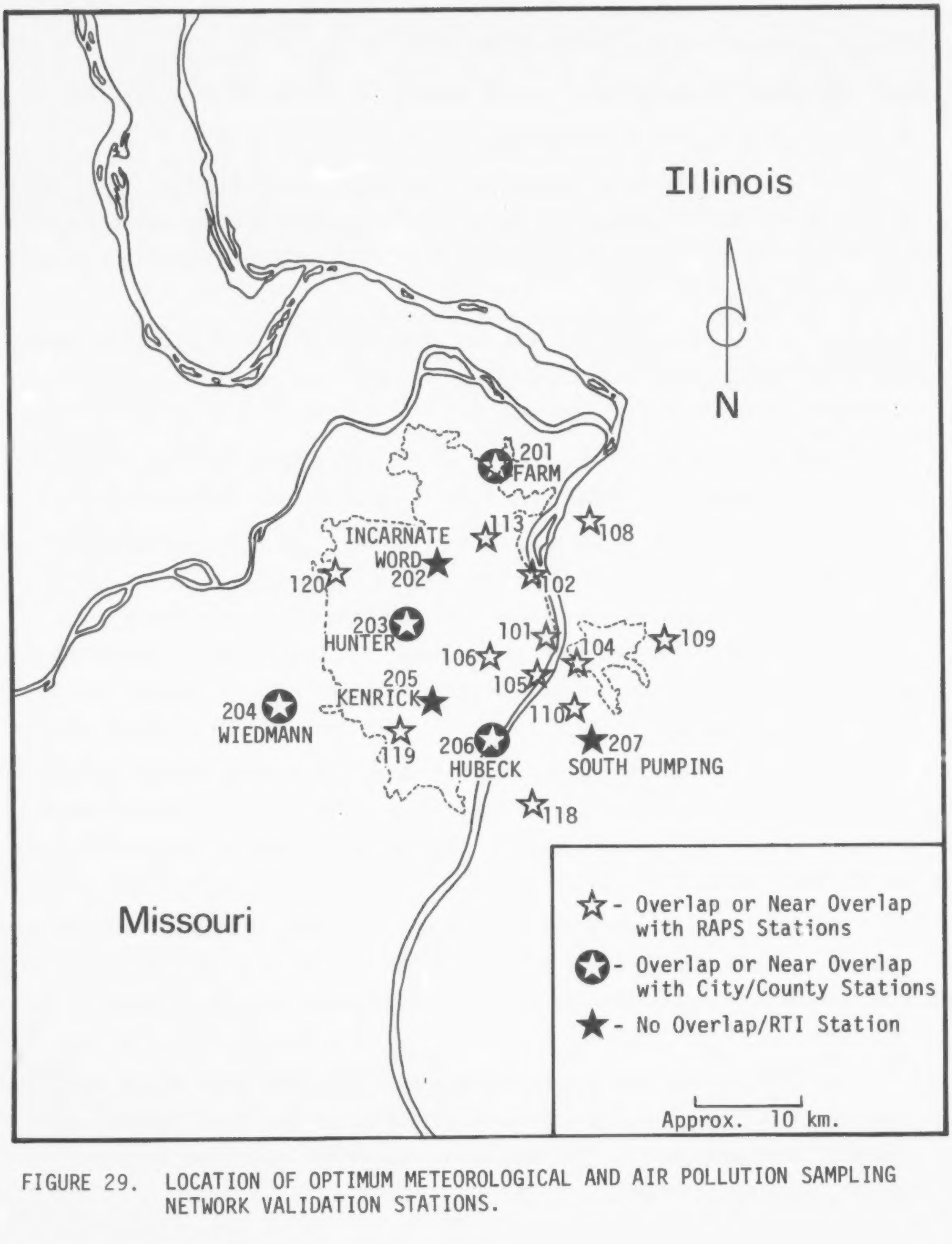

FIGURE 29. LOCATION OF OPTIMUM METEOROLOGICAL AND AIR POLLUTION SAMPLING NETWORK VALIDATION STATIONS.

Beckman 6800 gas chromatographs were used at the three RTI sites to conform with the instrumentation in the RAMS station and, thus, avoid any bias due to different instruments. With the cooperation of the St. Louis City/County Air Pollution Agencies, Beckman 6800's were also placed in each of the four city/county stations used in the study. RTI maintained the analyzers at these sites also.

Period of Data Collection

Measurements were made daily from 0000-2400 CST during the periods July 27 to August 15, 1975 and February 13 to March 5, 1976.

Parameters Measured	Instrument/Method Used
Total Hydrocarbons, Methane, and Carbon Monoxide	Beckman 6800 Gas Chromatograph Lower Detection Limit: 0.2 ppm for CO 0.05 ppm for CH_4 and THC
Wind Speed and Direction	Gill Wind System Speed indicated in miles per hour and direction in degrees of azimuth corrected to true north.

Calibration/Quality Control Procedures

Dynamic calibration techniques were used to calibrate each Beckman 6800 air quality chromatograph at specific intervals. The Beckman analyzers at each of the seven stations manned by RTI were calibrated every two days. The calibration consisted of a dynamic zero and an upscale calibration at 80 percent of the instrument's range. These instruments were also calibrated by EPA. The calibration data were used to update the transfer equations for converting strip chart readings to physical units.

A dynamic calibration procedure was also used by EPA to calibrate their Beckman 6800's. The EPA Beckman 6800's were calibrated daily to obtain updated transfer equations. Their daily calibration consisted of a dynamic zero and an upscale calibration of the instrument's range. Multipoint calibrations were accomplished weekly.

The wind system was calibrated before, after and periodically during the experimental period.

Location and Type of Data Available

To date, all data from the winter and summer field programs have been reduced. The analysis of the data is in progress and the results will be presented in later reports. Additional information may be obtained by contacting the EPA and NSF Project Officers

Publication

Vukovich, F. M., W. D. Bach, Jr., and C. A. Playton. Optimum Meteorological and Air Pollution Sampling Network Selection in Cities. Research Triangle Institute, Research Triangle Park, North Carolina. EPA Contract No. 68-03-2187. July 1978.

13.0 OTHER DATA SOURCES

Introduction

Routine data collection and special studies which may be of interest to RAPS researchers are documented in Section 13.0. In order to spatially broaden the RAPS perspective, descriptions are included of the closest National Weather Service upper air sounding stations as well as available satellite imagery and aerial photography.

Also described in this section are studies conducted by local planning commissions and private industries, all of which bear some relation to RAPS activities.

13.1 FEDERAL AGENCIES

13.1.1 U. S. DEPARTMENT OF COMMERCE

13.1.1.1 NATIONAL WEATHER SERVICE UPPER AIR SOUNDING STATIONS

Location

The four National Weather Service upper air sounding stations nearest St. Louis are Station 74433 in Salem, Illinois (38°39'N, 88°58'W); Station 72349 in Monett, Missouri (36°53'N, 93°54'W); Station 72532 in Peoria, Illinois (40°41'N, 89°41'W) and Station 72456 in Topeka, Kansas (39°04'N, 95°38'W). See Figure 30.

Parameters Measured	Instrument/Method Used
Cloud Type	Visually determined.
Barometric Pressure	One Kollsman aneroid barometer and a National Service mercury barometer indicating in millibars and inches of mercury respectively.
Ambient Air Temperature	Two ventilated mercury thermometers indicating dry and wet bulb temperatures in degrees Celsius.
Dew Point and Relative Humidity	Derived using a psychrometric calculator with readings from the ventilated thermometers.
Total Opaque Sky	Visually determined and recorded as tenths of sky coverage.
Wind Speed and Direction	Electra Speed F-420 wind system using a cup anemometer and directional vane. Speed is displayed in knots and directions as degrees with reference to true north.

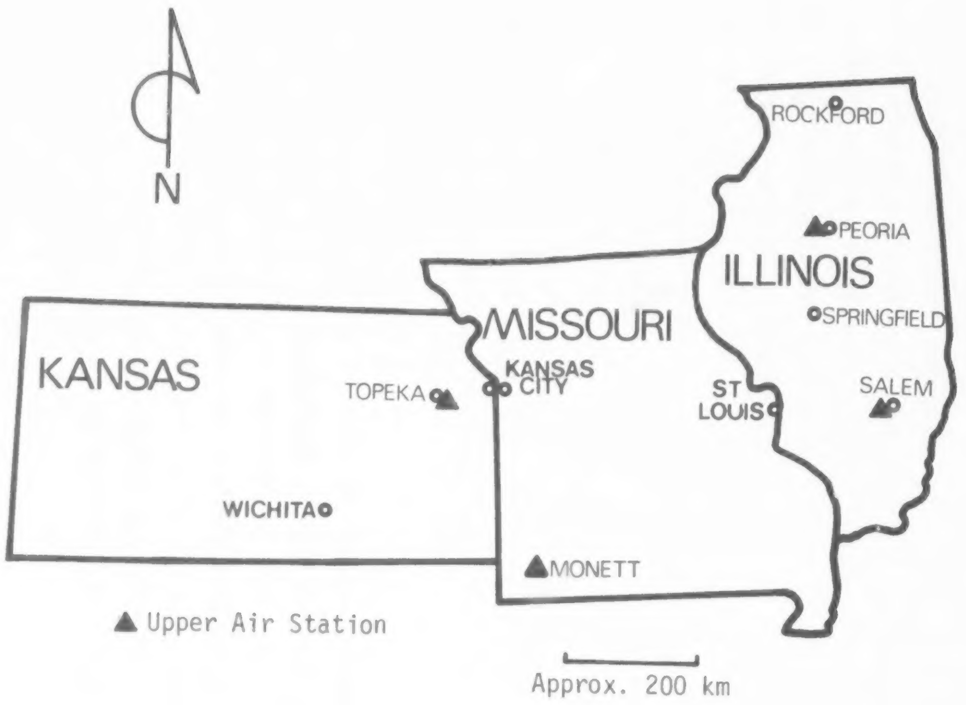

FIGURE 30. NATIONAL WEATHER SERVICE UPPER AIR STATIONS

Parameters Measured	Instrument/Method Used (continued)
Temperature, Relative Humidity, Wind Direction and Wind Speed Aloft	Viz 1680 MHz radiosonde equipped with a standard thermistor, hygristor and baroswitch. The unit is tracked with a WB-RT-57 radiotheodolite and associated angle printer. Temperature, relative humidity and barometric pressure are recorded on a Beukers receiver. The resulting data are entered into a Daconics Upper Air System microprocessor unit which computes the temperature and dew point in degrees Celsius, barometric pressure in millibars, wind direction in degrees azimuth with respect to true north and wind speed in knots. The radiosonde is carried aloft by a 600-gram balloon or under adverse conditions a 1200-gram balloon. Altitude is indicated in both meters and feet above mean sea level.

Procedures

Reduction methodologies are the same as those found in Federal Meteorological Handbook No. 3 - Radiosonde Observations. A pressure of 100 mb (approximately 16 km MSL) or less must be obtained to constitute a valid flight. Significant levels are selected whenever the temperature deviates ± 1°C from the established lapse rate or ± 2°C after the radiosonde attains a pressure of 100 mb, and whenever the relative humidity deviates 10% or more from the established trend. Relative humidity data are considered inaccurate at temperatures below -40°C.

Observation Interval

Radiosondes are released at 0000 and 1200 GMT (1800 and 0600 CST) each day. Surface observations are taken prior to each release. Observations and soundings have been taken prior to and throughout the RAPS program.

Calibration and Quality Control Procedures

Aneroid Barometer	The aneroid barometer is compared weekly to the National Weather Service mercurial barometer.
Mercury Barometer	The mercury barometer is calibrated yearly with two precision aneroid barometers from the NWS office in Kansas City, Missouri.
Mercury Thermometers	No routine calibration is performed.
Anemometer and Direction Vane	The anemometer and directional vane are calibrated yearly. A constant speed 900 rpm motor is used to calibrate the anemometer and solar noon is used to determine the orientation point for the directional vane.
1680 MHz Radiosonde	Each radiosonde is calibrated prior to release. An Electronic Craftsmen Baseline Check Box Type III is used to calibrate the thermistor and relative humidity element. The baroswitch is calibrated at the factory and set with the aneroid barometer before release.
WB-RT-57 Radiotheodolite	The instrument is oriented before each release. A radiotheodolite-theodolite comparison is performed monthly and immediate corrective action is taken if required.

Each observer is responsible for performing quality control checks on the preceding sounding. These quality control checks include trending, ordinate values, drift line corrections, baseline calculations and surface observation computations. Additional quality control checks are performed at the National Climatic Center.

Location and Type of Data Available

Data for each station are available as copies of computer printout or on magnetic tape. Data can be obtained from:

National Climatic Center
Federal Office Building
Asheville, NC 28801

(704) 258-2850
Ext. 683 Summaries and Micro-fiche
Ext. 203 Magnetic Tapes

Location of Information Concerning Data Collection

The procedures at the Salem, Illinois site are representative of the other three stations. Additional information concerning data collection can be obtained from:

Marvin Shore
National Weather Service
Salem Leckrone Airport
Route 2
Salem, IL 62881

(618) 548-4851

13.1.1.2 SATELLITE DATA SERVICES BRANCH

The National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, has been a major contributor in developing environmental uses for satellite technology. The Satellite Data Services Branch (SDSB) of the National Climatic Center, an arm of NOAA's Environmental Data Service, evolved in 1974 as a data source for the remotely sensed, satellite derived, earth monitoring information.

The SDSB files include imagery and photographs taken over the RAPS study area and period from NOAA administered environmental/meteorological satellites (ATS-3, SMS/GOES and ITOS/NOAA series), earth resources satellites (Landsat series), and NASA's Skylab missions.

Information on the NOAA administered satellites regarding operational periods, orbits, and pertinent sensors on board each craft are included in Table 19. Landsat and Skylab information is included in Section 13.1.2.

In addition to SDSB's central facility, seventeen browse files have been established throughout the country to increase public access to satellite imagery. Current addresses and telephone numbers can be obtained from SDSB. The browse files provide 16 mm microfilm imagery, standard catalogs, a data users handbook, a list of available data products and detailed ordering procedures.

Potential users can obtain the data they need or more information on the types of data available by calling or writing to:

Satellite Data Services Branch, D543
National Oceanic and Atmospheric Administration
World Weather Building, Room 606
Washington, DC 20233

(301) 763-8111

TABLE 19. NOAA SATELLITE INFORMATION

SATELLITE/ LAUNCH DATE	PERIOD OF OPERATION	ORBIT INFORMATION	TYPE OF SENSORS	OBSERVATION INFORMATION
Applications Technology Satellite (ATS-3) 11/67	5/70-12/74	Geostationary	Cloud Camera	Visible images - daytime only
Synchronous Meteorological Satellite (SMS-1) 5/74	6/74-1/76	Geostationary 35,892 km	Visible-Infrared Spin Scan Radiometer (VISSR)	Senses 8 visible channels (0.55 mm to 0.75 mm) with resolutions of 1-, 2-, 4-, or 7-1cm and 2 infrared channels (10.5 μm to 12.6 μm) with 7 km resolution
SMS-2 2/75	5/75-Present	Geocentric 35,789 km		
Geostationary Operational Environmental Satellite (GOES-1) 10/75	1/76-8/77 Replaced SMS-1	Geocentric 35,312 km	Space Environmental Monitor (SEM)	Measures proton, electron, and solar X-ray fluxes and magnetic fields.
GOES-2 6/77	8/77-Present Replaced GOES-1	Geocentric 35,785 km		

(continued)

TABLE 19 (continued)

SATELLITE/ LAUNCH DATE	PERIOD OF OPERATION	ORBIT INFORMATION	TYPE OF SENSORS	OBSERVATION INFORMATION
Improved TIROS Operational Satellite (ITOS/NOAA) NOAA-2 10/72	11/72- 3/74	Polar orbital 1,450 km	Scanning Radiometer	Senses using two channels: 0.5 μm to 1.0 μm visual channel with 4 km resolution and 10.5 μm to 12.5 μm infrared channel with 7 km resolution.
NOAA-3 11/73	3/74- 12/74	Geocentric 1,505 km	Very High Resolution Radiometer	Senses using two channels: 0.6 μm to 0.7 μm visual channel and 10.5 μm to 12.5 μm infrared channel both with 0.8 km resolution.
NOAA-4 11/74	12/74- Present	Geocentric 1,450 km	Vertical Temperature Profile Radiometer	
NOAA-5 7/76	9/76- Present	Geocentric 1,511 km	Solar Proton Monitor	

13.1.2 U. S. DEPARTMENT OF INTERIOR

13.1.2.1 EROS DATA CENTER

The U. S. Department of Interior established the Earth Resources Observation System (EROS) Program in 1966 to apply remote sensing techniques to the inventory, monitoring and management of earth resources. As a consequence, the EROS Data Center (EDC) was developed in 1973 primarily to archive and provide public access to this remotely sensed data. The EDC files include imagery and photography taken over the RAPS study area from NASA's Landsat satellites, Skylap missions, and research aircraft; and aerial photography acquired by the Department of Interior. EDC is the officially designated outlet for unclassified NASA aerial photography.

Information on the Landsat and Skylab craft regarding operational periods, orbits, and pertinent sensors on board each craft are included in Table 20 of this section. Aerial photography is summarized in Table 21.

EDC's central computer complex, with a data base of over 6 million images and photographs of the earth, is capable of performing a geographic search for information about imagery of a specific area. The computer printout received as a result of the search lists all images available over or close to the user's specified area of interest.

Training and assistance in the techniques required for the analysis of remotely sensed data are provided at EDC and the 7 Applications Assistance (AA) facilities. Orders for reproductions of data can be placed by mail, phone or visit. Standard photo products are available and any inquiries regarding products, ordering procedures and costs should be directed to:

Users Services
EROS Data Center
Sioux Falls, SD 57198

(605) 594-6511 Ext. 151

TABLE 20. LANDSAT AND SKYLAB INFORMATION

SATELLITE/ LAUNCH DATE	PERIOD OF OPERATION	ORBIT INFORMATION	TYPE OF SENSORS	OBSERVATION INFORMATION
LANDSAT-1 7/72	7/72- Present	Sun-synchronous polar orbit 920 km	Multispectral Scanner	Senses in scans 4 spectral bands simultaneously with 100 m resolution: a. two visible - 0.5 μm to 0.6 μm and 0.6 μm to 0.7 μm b. two near infrared 0.7 μm to 0.8 μm and 0.8 μm and 1.1 μm
LANDSAT-2 1/75	1/75- Present			
SKYLAB 2/73	5/73-6/73 7/73-9/73 11/73-2/74	Near-earth polar orbit 430 km	Multispectral Photographic Camera	Six lenses sensing in spectral bands from 0.5 μm to 0.9 μm with 50 m resolution. Four channels in black and white and two in color.
			Earth Terrain Camera	Sensing in spectral bands from 0.4 μm to 8.8 μm with 25 m resolution.
			Multispectral Scanner	Sensing in 13 spectral bands ranging from 0.4 μm to 12.5 μm.

TABLE 21. AERIAL PHOTOGRAPHY

TYPE OF SURVEY	AIRCRAFT ALTITUDE	SCALE	PHOTOGRAPH FORMAT
NASA High Altitude	from 1000 m to 18,000 + m	normally 1:120,000 and 1:60,000	23 x 23 cm film format available in black and white, color, or false-color infrared.
U.S. Geological Low Altitude (for mapping)	600 m to 12,000 m	latest photographs in 1974 at scale of 1:30,000 over St. Louis area.	23 x 23 cm film format in black and white.

13.1.2.2 NATIONAL CARTOGRAPHIC INFORMATION CENTER

The National Cartographic Information Center (NCIC) of the U. S. Department of Interior is a network of regional offices and state affiliates. All NCIC offices carry information on maps and charts, aerial and satellite photographs, satellite imagery, map data in digital form, and geodetic control data. NCIC offices also provide ordering assistance for aerial and satellite products available from the EROS Data Center.

The NCIC publishes a newsletter on an irregular basis which updates information, products, and services available throughout the country. Copies of the newsletter may be obtained by contacting:

The National Cartographic Information Center
Newsletter
U. S. Geological Survey
507 National Center
Reston, VA 22092

(703) 860-6045

A list of regional offices and state affiliates, and their addresses are shown in Tables 22 and 23 respectively.

TABLE 22. Regional Offices - National Cartographic Information Center

National Cartographic Information Center U. S. Geological Survey 507 National Center Reston, VA 22092	Gary W. North 703-860-6045 FTS 928-6045
Eastern Mapping Center National Cartographic Information Center U. S. Geological Survey Reston, VA 22092	Frederick Lavery 703-860-6336 FTS 928-6336
Mid-Continent Mapping Center National Cartographic Information Center U. S. Geological Survey 1400 Independence Road Rolla, MO 65401	William M. Voight 314-364-3680, ext. 107 FTS 276-9107
Rocky Mountain Mapping Center National Cartographic Information Center U. S. Geological Survey Box 25046, Stop 504, Federal Center Denver, CO 80225	Raymond E. Hill 303-234-2326 FTS 234-2326
Western Mapping Center National Cartographic Information Center U. S. Geological Survey 345 Middlefield Road Menlo Park, CA 94025	Lee W. Aggers 415-323-8111, ext. 2427 FTS 467-2427
National Space Technology Laboratories National Cartographic Information Center U. S. Geological Survey Building 1100 NSTL Station, MS 39529	Henry T. Wvehlak 601-688-3544 FTS 494-3544
EROS Data Center U. S. Geological Survey Sioux Falls, SD 57198	Kent N. Swanjord 605-594-6511, ext. 507 FTS 784-7507

TABLE 23. State Affiliates - National Cartographic Information Center

Arizona Arizona Department of Revenue Arizona Resources Information System 1624 West Adams, Room 302 Phoenix, AZ 85007	Michael S. Castro 602-271-4061 FTS 765-4061
Georgia Department of Natural Resources Geologic & Water Resources Division 19 Martin Luther King Jr. Drive Atlanta, GA	Sam M. Pickering, Jr. 404-656-3214 FTS 404-656-3214
Minnesota Minnesota State Planning Agency Environmental State Planning Agency 15 Capitol Square 550 Cedar Street Saint Paul, MN 55101	Donald Yeager 612-296-2613 FTS 776-2613
New Mexico Technology Applications Center University of New Mexico 2500 Central Avenue, W. E. Albuquerque, NM 87131	Dr. Stanley A. Morain 505-277-3622 FTS 474-5511 ask for 277-3622
South Carolina South Carolina Land Resources Conservation Commission 2221 Devine Street, Suite 222 Columbia, SC 29205	Nick Bayne 803-758-7197, ext. 41 FTS 677-5011 ask for 758-7197 ext. 41
Texas Texas Natural Resources Information System P. O. Box 13087 Austin, TX 78711	David L. Ferguson 512-475-3321 FTS 734-5011
West Virginia West Virginia Geological and Economic Survey West Virginia Cartographic Center P. O. Box 879 Morgantown, WV 26505	Dr. Peter Lessing 304-292-6331 FTS 923-7611 ask for 292-6331, ext. 256

13.1.3 U. S. DEPARTMENT OF AGRICULTURE

The Agriculture Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture maintains the Aerial Photography Field Office (APFO) to archive and provide public access to aerial photography and files of Landsat and Skylab imagery.

Information on the Landsat and Skylab satellites are given in section 13.1.2.

The aerial photography taken by the ASCS is available over the RAPS study area by county. Photographs were taken at a scale of 1:20,000 and 1:40,000 in more recent years.

The most recent photography, by county, is given below:

St. Louis City and County	1971
St. Charles	1971
Franklin	1972
Jefferson	1966
Madison	1968
Monroe	1968
Jersey	1968
St. Clair	1973

APFO maintains a browse file to serve its users and has begun developing a geographic search and inquiry system. The browse file provides microfilm copies of its holdings plus catalogs, photographic indices, and trained personnel to assist the user in ordering.

Images and photographs may be ordered directly from APFO. Inquiries regarding products, ordering and costs should be directed to:

U. S. Dept. of Agriculture - ASCS
Aerial Photography Field Office
Administrative Services Division
2505 Parley's Way
Salt Lake City, UT 84109

(801) 524-5856

13.1.4 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA established the National Space Science Data Center (NSSDC) to further practical use of reduced data obtained from space investigations and to provide investigators with a repository for such data. The Data Center supports data users and provides a browse file, technical assistance and use of equipment at the facility.

Considerable data from many spacecraft are archived at NSSDC as NASA launches and establishes the orbits of all satellites, but data most pertinent to the RAPS study are from NIMBUS 5 and 6. Details of these satellites including operational periods, orbits, and sensors on board are documented in Table 24. Information on the Landsat and Skylab satellites are given in section 13.1.2.

Due to the experimental nature of these satellites, it is recommended that a user obtain the NIMBUS 5 and 6 User's Guide and Data Catalogs from NSSDC for specifics regarding the various sensors on board and their respective procedures for archiving and data acquisition.

Potential users may obtain the catalogs, data, or more information on the types of data available by calling or writing to:

National Space Science Data Center
Goddard Space Flight Center
Code 601
Greenbelt, MD 20771

(301) 982-6695

TABLE 24. NIMBUS 5 AND 6 INFORMATION

SATELLITE/ LAUNCH DATE	PERIOD OF OPERATION	ORBIT INFORMATION	EXPERIMENTS/SUBSYSTEMS
NIMBUS 5 12/72	12/72- 3/75	Polar Orbital 1100 km	Temperature Humidity Infrared Radiometer (THIR) Subsystem Surface Composition Mapping Radiometer (SCMR) Experiment Electrically Scanning Microwave Radiometer (ESMR) Experiment Infrared Temperature Profile Radiometer (ITPR) Experiment Selective Chopper Radiometer (SCR) Experiment NIMBUS E Microwave Spectrometer (NEMS) Experiment
NIMBUS 6 6/75	6/75- Present	Polar Orbital 1100 km	Temperature Humidity Infrared Radiometer (THIR) Subsystem High Resolution Infrared Radiation Sounder (HIRS) Experiment Scanning Microwave Spectrometer (SCAMS) Experiment Electrically Scanning Microwave Radiometer (ESMR) Experiment Earth Radiation Budget (ERB) Experiment Limb Radiance Inversion Radiometer (LRIR) Experiment Pressure Modulator Radiometer (PMR) Experiment Tropical Wind Energy Conversion and Reference Level Experiment (TWERLE) Tracking and Data Relay Experiment (T&DRE)

13.2 CITY AND COUNTY AGENCIES

13.2.1 EAST-WEST GATEWAY COORDINATING COUNCIL

The East-West Gateway Coordinating Council (EWGCC) is a regional planning agency for the greater St. Louis area. It is funded by its member counties of Monroe, Madison and St. Clair in Illinois, and Franklin, Jefferson, St. Charles and St. Louis in Missouri, as well as the City of St. Louis. Locally elected officials serving as members of its Board of Directors work areas of transportation, environment and housing.

Two pertinent air pollution related publications are available from EWGCC. The first, St. Louis Air Quality Assessment, analyzes air pollution trends in regard to the region's long-range transportation plan. This report was jointly funded by the Illinois Department of Transportation, Missouri State Highway Commission, and the Federal Highway Administration. The study utilizes the Kansas Air Pollution Package (KAPP). (This model was previously tested and accepted by EWGCC in a report titled Air Quality Assessment Procedure Selection.) KAPP generates and disperses pollutants due to traffic and plots the concentrations for comparison. This study compares the pollutant concentrations derived from KAPP for the 1975 with those projected for 1995. A comparison of KAPP predictions and actual monitored data is also included in the report.

The second report, Air Quality--Public Information and Transportation Strategies was funded by EPA under contract 68-02-2531. The paper summarizes air quality activities undertaken by EWGCC. These activities include conducting an area wide public information campaign, and promoting and developing various transportation control strategies (such as vanpool projects, a transit promotion project, and a traffic flow improvement) designed to reduce excessive air pollution in the St. Louis air quality control region.

Reports may be obtained from:

M. James Bogart
Transportation Planner
East-West Gateway Coordinating Council
Pierce Building, Suite 1200
112 N. 4th Street
St. Louis, MO 63102

(314) 421-4220

Publications

East-West Gateway Coordinating Council, Transportation Planning Staff. St. Louis Air Quality Assessment. St. Louis, Missouri. April 1977.

East-West Gateway Coordinating Council. Air Quality Assessment Procedure Selection. St. Louis, Missouri. Funded by Federal Highway Administration. June 1976.

Bogart, M.J. Air Quality--Public Information and Transportation Strategies. East-West Gateway Coordinating Council, St. Louis, Missouri. EPA Contract 68-02-2531. June 1977.

13.2.2 SOUTHWESTERN ILLINOIS PLANNING COMMISSION

The Southwestern Illinois Planning Commission, utilizing data provided by other agencies, has published a pollution study, Air Quality in the Metro East Area. This study was prepared for the East-West Gateway Coordinating Council and financed in part by the Federal Highway Administration. The report presents an overview of air pollution--its sources, effects and controls--and an analysis of air pollution data for particulates, sulfur dioxide, nitrogen oxide, carbon monoxide and ozone for 1975, as collected by the Illinois Environmental Protection Agency. There is a graphical representation of these five pollutants on a monthly basis for 1975 and on an annual basis for each reporting station. Analysis revealed that suspended particulate matter was the only pollutant which exceeded the Illinois State standards during 1975, however, the concentrations of all pollutants had increased from 1974 to 1975.

Further information and copies of the report can be obtained by contacting:

Gregory J. Sterns
Southwestern Illinois Planning Commission
203 W. Main Street
Collinsville, IL 62234

(618) 344-4250

Publication

Southwestern Illinois Planning Commission. Air Quality in the Metro East Area. Collinsville, Illinois. June 1976.

13.3 PRIVATE INDUSTRIES

13.3.1 SURDEX CORPORATION

The SURDEX Corporation, located at the Spirit of St. Louis Airport in Chesterfield, Missouri, is a commercial operation specializing in aerial photogrammetry. SURDEX has performed periodic aerial surveilance of the St. Louis area since April 1971. Subsequent surveys were flown in April of 1973, 1975, and 1977, all, with the exception of 1973, using a scale of 1:24,000. The 1973 scale is 1:16,800. In addition to the surveys made by SURDEX for their own use, other flights have been made for various contractors and agencies. Images from these flights are available but normally do not include full coverage of the St. Louis area and are at irregular time intervals.

SURDEX will process requests for aerial coverage for specific dates and, if coverage for that date does exist, will provide positive prints from the flight.

Requests for aerial photographs and pricing information should be made to:

SURDEX Corporation
Spirit of St. Louis Airport
24 Mercury Boulevard
Chesterfield, MO 63017

(314) 532-3427

13.3.2 UNION ELECTRIC REFUSE FUEL DEMONSTRATION PROJECT

Principal Investigators

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Harry Freeman
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Funding

EPA Contract No. 68-02-1871
EPA Contract No. 68-02-1324, Task No. 4

Period of Performance May 1975 - February 1978

Summary

The St. Louis-Union Electric Refuse Fuel Demonstration System was the first demonstration plant in the United States to process raw municipal waste for use as a supplementary fuel in a utility boiler. Two separate facilities comprise the system--a processing plant operated by the City of St. Louis and Union Electric's Meramec power plant shown in Figure 31.

At the processing plant, raw waste is separated into light and heavy fractions. The light fraction, consisting of approximately 80 to 85 percent of the incoming refuse, is processed forming the refuse derived fuel (RDF), which is then hauled 29 km by truck to the Meramec power plant where the firing operations occur.

This system provided the opportunity to evaluate the equipment and facilities for the production and firing of RDF and to assess the gaseous, acqueous and solid waste emissions associated with processing and firing RDF. In 1974, EPA contracted the Midwest Research Institute (MRI) to implement a detailed evaluation of these parameters. Due to the nature of the RAPS program, only the gaseous emissions will be discussed in this summary, although all aspects of the study are included in the MRI reports.

The first report assessed emission rates at the processing site for the air density separator (ADS) cyclone and hammermill (HM) cyclone. The most significant result of the emission sampling was that the emissions from the ADS cyclone averaged 22.68 kg/hr. At a normal processing rate this represents an emission factor of .51 kg/metric ton of processed refuse. In all cases, at least 80% of the particles were above 10 μm in size. The ADS emission rate is significant, indicating a need to reduce emissions, possibly by redesign, or by installation of a suitable particulate control device.

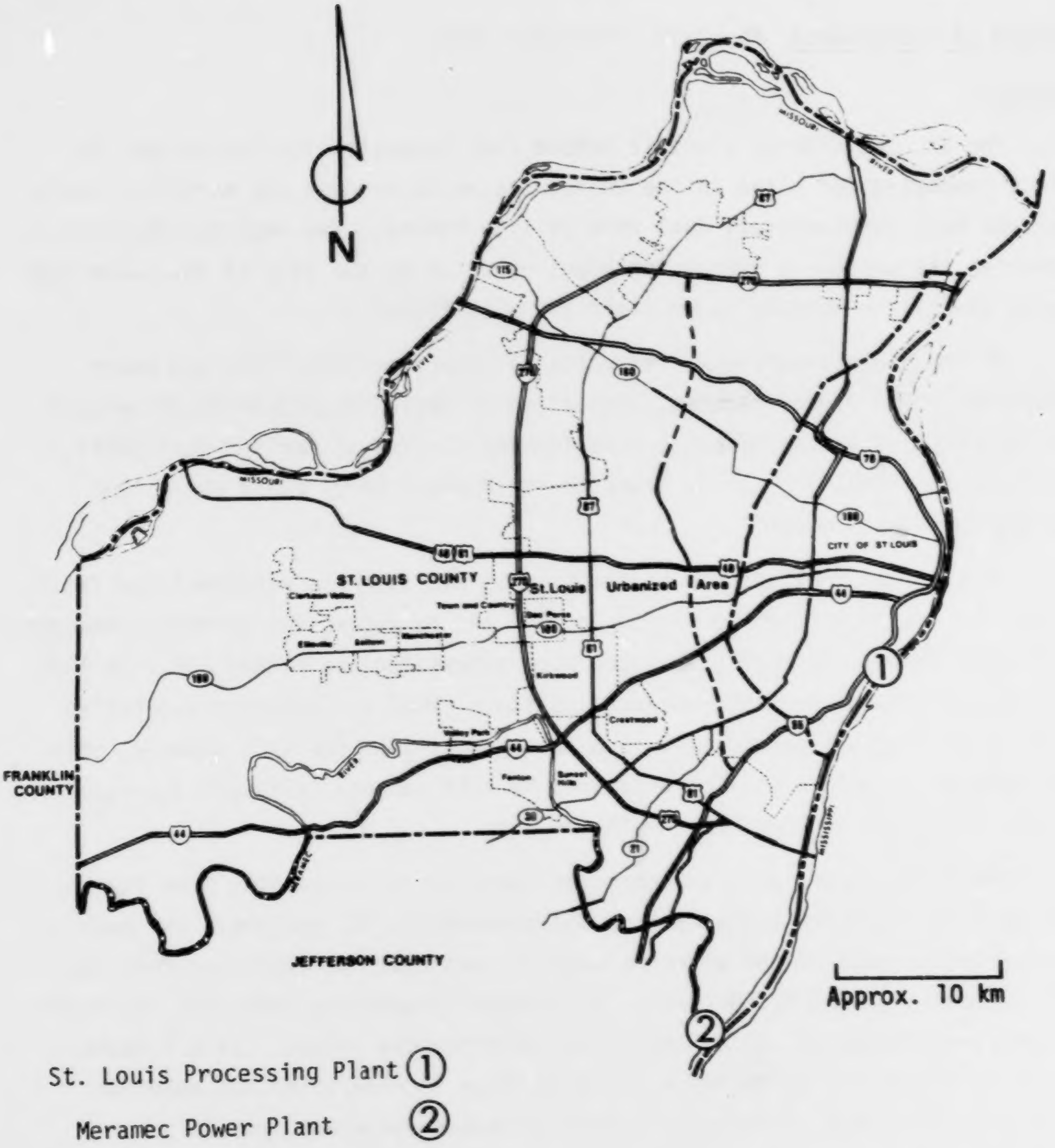

FIGURE 31. LOCATIONS OF REFUSE PROCESSING AND FIRING FACILITIES

The particulate sampling of the emissions from the ADS cyclone was performed using a hi-vol sampler, equipped with a 23.11 mm diameter probe tip, sampling for 2 minutes at 14 points along each of the associated duct traverses. Particle size distribution of the ADS cyclone discharge was determined using the Anderson High Volume cascade impactor and precyclone provided by EPA.

Emissions from the HM cyclone were much lower than those from the ADS cyclone and were judged not a significant source of particulate emissions.

The second report evaluated the equipment and facilities for the storage and firing of refuse derived fuel at the power plant and assessed the environmental emissions associated with these processes.

In order to evaluate the potential environmental impact of particulates and gaseous emissions from the power plant, a test program was devised to compare emissions when burning Orient 6 coal with those from combinations of Orient 6 coal and RDF. Tests were performed to evaluate both conventional and potentially hazardous pollutants. The philosophy behind the tests was that there would be a greater number of conventional emission tests covering a wider range of boiler loads and various coal plus RDF combinations, while the tests for potentially hazardous pollutants would be fewer in number but would include more extensive analysis of the pollutants. A brief summary of the pollutants analyzed follows. All pollutants were monitored at both the inlet and outlet of the electrostatic precipitator.

Except for chloride emissions, the firing of coal plus RDF did not produce any major changes in the emission of gaseous pollutants compared with the firing of Orient 6 coal only. Chloride emissions were found to increase about 30%. For carbon monoxide, nitrogen oxides, hydrocarbons and sulfur oxides, all emission levels remained relatively constant regardless of whether coal plus RDF or coal only was used.

Air emission of potentially hazardous pollutants associated with the burning of coal or coal plus RDF were measured in two sets of tests. The concentrations of some pollutants did increase when coal and RDF were fired compared to concentrations for the coal only conditions. Most of the increases are associated with elements that exist in higher concentrations in

RDF than coal. Those elements noted to increase with the burning of RDF are beryllium, cadmium, copper, lead, mercury, titanium, zinc and fluorine.

The MRI tests for particulate emissions were all conducted using EPA Method 5. Particulate loadings prior to entering the electrostatic precipitator remained constant, independent of boiler load or percent of RDF. In contrast, particulate loadings increased at the outlet end of the electrostatic precipitator with increased boiler loads and when RDF was fired with the coal.

An assessment of potentially hazardous emissions showed that three pollutants (chlorine, bromine and lead) may represent an environmental problem even when burning coal only, with RDF compounding the problem.

A third MRI Report evaluates airborne bacterial and viral emissions from the processing facility and the power plant.

All data resulting from these studies are contained in the three reports and are available through:

Carlton Wiles
Environmental Protection Agency
Solid and Hazardous Waste Research Laboratory
Cincinnati, OH 45268

(513) 684-7881

Publications

Shannon, L.J., D.E. Fiscus, and P.G. Gorman. St. Louis Refuse Processing Plant: Equipment, Facility, and Environmental Evaluations. Midwest Research Institute, Kansas City, Missouri. Task No. 4, EPA Contract 68-02-1324. May 1975. EPA-650/2-75-044.

Fiscus, D.E., P.G. Gorman, M.P. Schrag, and L.J. Shannon. St. Louis Demonstration Final Report: Refuse Processing Plant Equipment, Facilities and Environmental Evaluations. Midwest Research Institute Environmental Systems Section, Kansas City, Missouri. EPA Contracts 68-02-1324 and 68-02-1871. April 1977.

Gorman, P.G., L.J. Shannon, M.P. Schrag, and D.E. Fiscus. St. Louis Demonstration Project Final Report: Power Plant Equipment, Facilities and Environmental Evaluations. Midwest Research Institute Environment Systems Section, Kansas City, Missouri. EPA Contract 68-02-1871. February 1978.

13.3.3 GREAT LAKES CARBON SOURCE TESTING

Principal Investigator

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Consultants, Inc.
25711 Southfield Road
Southfield, MI 48075

(313) 424-8860

Project Officer

Kirk E. Foster (MD-7)
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Research Triangle Park, NC 27711

(919) 541-4571

Funding EPA Contract No. 68-02-1408, Task No. 14

Period of Performance

Summary

The EPA Division of Stationary Source Enforcement retained Clayton Environmental Consultants to study coke-side emissions at coke-oven batteries producing foundry coke at Great Lakes Carbon Corporation, 526 E. Catalan, St. Louis, Missouri.

Coking is a process by which coal is destructively distilled in a low oxygen atmosphere to produce volatile gases and a residue of relatively non-volatile coke. The coke is produced in a battery of coke ovens with each individual oven separated by a heating flue. Volatile gases driven off during coking are processed and partially recycled and used to fire the ovens. After completion of the coking process, usually about 28 hours, a ram operated from the "push side" of the oven forces the charge out a door on the "coke side" and through a guide into a rail mounted quench car. After the charge is deposited in the quench car, the car moves along the rail to the quench tower where the incandescent coke is sprayed with water to reduce its temperature.

One of the three batteries of ovens at Great Lakes Carbon, Battery A, is equipped with a shed-type enclosure designed to contain particulate and gaseous emissions produced on the coke side of the battery during coking and coke pushing. The vertical wall of the shed does not extend completely to the ground to allow clearance of the quench car. The shed is also open at each end. An induced draft fan exhausts the shed enclosure through ductwork to the quench tower for discharge to the atmosphere.

At the time of the study, construction of a shed over the B and C Batteries was in progress. Nevertheless, coke-side emissions from B and C ovens escaped directly to the atmosphere.

The purpose and objectives of this study were primarily concerned with shed analysis and included the development of:

1) Basic engineering data concerning process emissions, fugitive emissions from the shed, capture efficiency of the shed, and quantity and characteristics of contaminants present in the shed exhaust.
2) Other basic engineering data for specification of future retrofitted control devices for removal of air contaminants in the shed exhaust.
3) Correlations to relate these measurements to process conditions.

Measured contaminants included:

1. Particulate emissions during the coke pushing cycle
2. Particulate emissions during the non-pushing cycle
3. Particle size distribution during the pushing cycle
4. Sulfur dioxide and trioxide
5. Polynuclear aromatic hydrocarbons
6. Carbon monoxide
7. Gaseous hydrocarbons
8. Phenolics

In addition to measuring emissions from the A Battery, EPA personnel monitored some visible emission parameters including the "degree-of-greenness" (due to insufficiently carbonized coke) of each push beneath the shed during sampling, visual opacity of the quench tower exit gases (the ultimate point of discharge to the atmosphere from the shed), and optical density, measured with a gas transmissometer installed temporarily on the exhaust gas duct and located between the shed and the quench tower.

Exhaust gas sampling was conducted using EPA standard source testing methods, or similar methods modified to suit this particular source. While sampling, all process operating conditions were monitored to assure typical operating conditions.

Data collected indicated that the shed is less than 100% efficient in capturing coke-pushing emissions, the average capture efficiency of the shed during pushing being 91%. Considering both the pushing and nonpushing cycles, the overall average percent capture efficiency of the shed appears to be about 96%.

Both wind speed and direction were factors affecting the rate of emissions escaping from the shed system. Increased leakage was also observed as a result of pushing occurring near the end of the shed, especially the downwind end, and as a result of pushes with a high degree of greenness.

During conditions which were relatively conducive to leakage, average emissions escaping the shed ranged from 0.0081 to 0.090 pounds per ton with an average of 0.038 pounds per ton of dry coal fed, or 0.050 pounds per ton of coke produced.

These figures could be considered quite conservative, since in addition to the above mentioned variables affecting emissions, less favorable operational procedures and maintenance practices such as an increase in the number of leaking doors or the intensity of door leakage, will produce impact on daily emission rates which could easily range as high as 5 to 6 times the emission rates determined during the EPA study.

Technical data and results of this study are contained in a three volume report and may be obtained from:

Kirk E. Foster (MD-7)
Environmental Protection Agency
Division of Stationary Source Enforcement
Research Triangle Park, NC 27711

(919) 541-4571

Publications

Source Testing of a Stationary Coke-Side Enclosure, Great Lakes Carbon Corporation, St. Louis, Missouri, Volume I. Clayton Environmental Consultants, Inc., Southfield, Michigan. Task No. 14, EPA Contract 68-02-4108. August 1977. EPA-340/1-77-014a.

Source Testing of a Stationary Coke-Side Enclosure, Great Lakes Carbon Corporation, St. Louis, Missouri, Volume II. Clayton Environmental Consultants, Inc., Southfield, Michigan. Task No. 14, EPA Contract 68-02-4108. August 1977. EPA-340/1-77-014b.

Source Testing of a Stationary Coke-Side Enclosure, Great Lakes Carbon Corporation, St. Louis, Missouri, Volume III. Clayton Environmental Consultants, Inc., Southfield, Michigan. Task No. 14, EPA Contract 68-02-4108. August 1977. EPA-340/1-77-014c.

14.0 EMISSION INVENTORIES

Introduction

A major division of the RAPS field measurement program consisted of the emission inventory effort. The accuracy of any attempt to predict air quality through regional air quality simulation models is proportional to the overall accuracy of these inventories.

Although some overlap exists, Section 14.0 is divided into three broad classes of effort. The first describes the development of emission inventory methodologies for various emission categories and spatial configurations, such as point, line and area sources.

The second section describes the efforts in compiling the actual emission inventories, similarly classified into various categories and source types. The final section treats the data handling and verification processes including precision analysis, source testing, and quality assurance.

14.1 EMISSION INVENTORY METHODOLOGIES

14.1.1 FIELD EXPERIMENT EMISSION INVENTORY PROCUREMENT

Principal Investigator	Task Coordinator
Fred E. Littman Rockwell International Air Monitoring Center 11640 Administration Drive Creve Coeur, MO 63141 (314) 567-6722	Charles C. Masser (MD-14) Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, NC 27711 (919) 541-5285

Funding EPA Contract No. 68-02-1081, Task Order No. 17

Period of Performance February 1974 - January 1975

Summary

Supplementing the studies in the mainstream of the RAPS program were various field experiments. Investigating photochemical reaction mechanisms or trying new approaches to aerosol characterization are good examples. It was realized early in the RAPS program that these special field studies would require more detailed information on the emission of pollutants than was available from the RAPS emission inventory data base. Such information could only be supplied through special emission inventories. In fulfillment of Task Order No. 17 requirements, procedures were established by means of which special emission inventories would be procured. These procedures may be summarized briefly as follows:

1) The special data requirements for a field study are noted and a survey of exising RAPS emissions data carried out to see if the requirements are met.

2) If RAPS emissions data are deemed insufficient, the special requirements are reviewed to ascertain what is really needed, whether it be better temporal resolution, better spatial resolution, etc.

3) A request for a task order assignment is made.

4) Task order execution is begun. Source identification and contact is made, and data collection is carried out.

The normal times required to execute each of the above steps were estimated in the final report for this task order. More detail on each of the steps may be found therein.

A general survey of RAPS emission inventory data is included in the task order final report along with a description of the system for storing and handling the data. No data were collected as part of Task Order No. 17. The final report, referenced below, was the end product. Additional information may be obtained from the EPA Task Coordinator.

Publication

Littman, F. E. Special Emission Inventories for Field Studies. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 17 Final Report, EPA Contract 68-02-1081. January 1975.

14.1.2 POINT SOURCE EMISSION INVENTORY METHODOLOGY

Principal Investigator

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Rockwell International
Air Monitoring Center
11640 Administration Drive
Creve Coeur, MO 63141

(314) 567-6722

Task Coordinator

James Southerland (MD-14)
Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

(919) 541-5285

Funding EPA Contract No. 68-02-1081, Task Order No. 16, Phase I

Period of Performance April - October 1974

Summary

Phase I of Task Order No. 16 developed a methodology for inventorying emissions from point sources. This included proposing a method of measuring and/or estimating hourly emissions for the principal sources of pollution in the St. Louis Air Quality Control Region (AQCR). Initially, attention was focused on SO_2 emissions, since the major polluters in the St. Louis area invariably emit large quantities of SO_2 and, therefore, emissions of SO_2 indicate general emission levels. Also included as pollutants of interest were CO, NO_X, HC, particulates, and heat emissions.

Existing emission inventories were reviewed, and the role of the National Emission Data System (NEDS) inventory was discussed. The RAPS emission inventory utilized the NEDS information on the annual emission of SO_X, CO, NO_X, HC and particulates as a starting point and general guideline. Emission sources were classified according to mobile or stationary, point or area. The methodology of Task Order No. 16 deals with stationary point sources exclusively, though some of the techniques discussed are of general applicability.

Procedures for acquiring and recording point source data were proposed.

To start with, a survey of the sources, involving contact with appropriate industrial personnel, would be carried out. This was to obtain access to data which could be used for calculating emissions. Stack monitoring data were to be obtained whenever possible. The sources would be classified as either major or minor. Data would then be acquired in various forms: stack analyses, fuel consumption or process data, and derivations from operational data. The final phase consisted of putting the data into machine readable form. Raw data in the form of strip charts, steam charts, computer printouts, and production logs, would be used by data clerks in the transfer of data to coding forms. To facilitate the process of coding data, a set of instructions was drawn up. Once data were coded and keypunched, the System 2000 data handling system will be used to process all data on the Univac 1110 computer at RTP.

The methodology was described completely in the Phase I final report. No data were collected for Phase I. The final report, referenced below, was the end product. Additional information can be obtained from the EPA Task Coordinator.

Publication

Littman, F. E. Regional Air Pollution Study Point Source Methodology and Inventory. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 16 Phase I Final Report, EPA Contract 68-02-1081. October 1974. EPA-450/3-74-054.

14.1.3 RESIDENTIAL AND COMMERCIAL AREA SOURCE METHODOLOGY

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Funding EPA Contract No. 68-02-1003

Period of Performance January - December 1974

Summary

To assess the impact of residential and commercial area source emissions, methodologies for their estimation were developed. The methodologies were applied to the St. Louis AQCR, resulting in an emission inventory with grid square spatial resolution (using the RAPS Grid System unit Section 14.3.1) and hourly temporal resolution. Data supporting the methodologies and inventories were collected from various sources in the following categories:

1) Fuel usage
2) Residential and commercial-institutional land use
3) Gasoline sales
4) Paint sales
5) Use of dry cleaning fluids
6) Solid waste disposal
7) Uncontrolled fires

The latest available data were used; their sources as well as the period on which they are based are shown in Table 25. Methods were developed for

TABLE 25. RESIDENTIAL AND COMMERCIAL DATA SOURCES AND DATES

Nature of Data	Source	Date
Land Use Reports (Commercial/Residential)	Existing Land Use Update and Analysis. East-West Gateway Coordinating Council	1971 - 1972
City Planning and Development Statistics	St. Louis Development Program, St. Louis City Planning Commission	1974
Population and Commercial Land Use Density	U.S. Bureau of Census Fourth Count Computer Summary Tapes	1970
Population	U.S. Bureau of Census Population Estimates and Projections for 1972 - 1973	1972 - 1973
Natural Gas Usage	Laclede Gas Company Analysis of Natural Gas Flow and Billing Data	1974
Fuel Usage	National Emission Data System (NEDS) Stationary Source Fuel Summaries Report	1970 - 1973
Paint Usage	National Paint Coating Association Statistics	1973 - 1974
Gasoline Sales	Department of Revenue	1974
Gasoline Stations Per County	1972 County Business Patterns	1972
Solid Waste Disposal	An emission inventory prepared by St. Louis County	1973
Structural Fires (Number and Location)	State statistics	1974

estimating hourly emissions of SO_2, NO_X, CO, HC and particulates per grid square.

Residential and commercial-institutional consumption of fuels for space heating were treated separately. Estimates of residential fuel consumption were based on census data for housing units using natural gas, fuel oil, etc. The census data were distributed to grid squares by superimposing the RAPS Grid System on census tract maps. Emissions were estimated from fuel consumption using EPA AP42 emission factors and NEDS Fuel Summaries. Commercial-institutional fuel was derived from commercial land use, introducing weighting factors for areas in which a particular fuel is used heavily. Emissions were estimated using AP42 emission factors in a procedure similar to that used with residential sources. Temporal distribution of fuel use was accomplished by assuming residential and commercial-institutional fuel use patterns to be identical. The temporal distribution pattern was evolved from hourly natural gas flow data coupled with meteorological data showing the temperature and wind speed dependence of fuel consumption.

Evaporative losses to the atmosphere from dry cleaning, surface coating, and gasoline handling were estimated. Characteristic emissions on a per capita basis were established and the emissions determined for each grid square by allocating the total projected county emissions in proportion to commercial land use in the grid square for gasoline handling and dry cleaning, and in proportion to population for surface coating.

Since emissions related to the disposal of solid wastes are primarily confined to the commercial-institutional sector and municipal incinerators, NEDS county emission totals were allocated to grid squares in proportion to the amount of commercial-institutional land use in each grid square.

Structural and forest fires are included under the heading "uncontrolled fires". Since no statistics are available on forest fires and only statewide statistics on structural fires, a reliable estimate of emissions was next to impossible. For the inventory, the state structural fire totals were apportioned to the county level on the basis of population. Using AP42 emission factors, emission estimates were derived.

Computer software has been developed to calculate emissions from residential and commercial-institutional operations for each of the grid squares in the St. Louis AQCR. Temporal resolution is limited to emission per hour or longer intervals. All data used in the calculations are stored in the emission inventory data base at RTP. Emission values generated from these data are readily available, once units and temporal resolution are specified. Those interested in obtaining residential and commercial-institutional emission estimates should contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

The final report, containing a detailed description of methodologies and inventory, is referenced below. Additional information can be obtained from the EPA Project Officer.

Publication

Environmental Science and Engineering, Inc. Residential and Commercial Area Source Emission Inventory Methodology for the Regional Air Pollution Study. EPA Contract 68-02-1003. September 1975. EPA-450/3-75-078.

14.1.4 METHODOLOGY FOR INVENTORYING HYDROCARBONS

Principal Investigator

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Project Officer

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Funding EPA Contract No. 68-02-1006, Task Order No. 7

Period of Performance January - March 1976

Summary

As a response to one of the special needs of modelers, a methodology for obtaining detailed hydrocarbon emissions data was produced.

One of the principal considerations expressed in this methodology was to catalog data in a format consistent with the NEDS emission inventory. Consequently the status of the NEDS inventory format was used as a reference point for the hydrocarbon methodology.

A thorough description of the region under consideration was the first step in the hydrocarbon inventory. This included obtaining sufficient statistical information to apportion emissions from individually unidentifiable or "area sources", by obtaining all necessary maps (traffic count, topographical, etc.) and a listing of manufacturers in the area. All point sources were assigned Universal Transverse Mercator (UTM) coordinates after location on U. S. Geological Survey maps.

Broad categories of types of hydrocarbon sources were identified: fuel combustion, solid waste, process and evaporative sources. Highly detailed questionnaires were proposed for such operations as degreasing,

surface coating, dry cleaning, and bulk storage of petroleum products which, when sent to appropriate personnel in local industry, would request the necessary information. Specific examples of information requested were: amount of degreasing solvent used in gallons/year, paint usage in gallons/year, and a breakdown of solvent usage by type and amount. Development of mailing lists and follow-up procedures for questionnaires were discussed.

Data obtained would be processed by one of two methods: manually or utilizing a computer data handling system. Manual processing required an analysis of the extent of survey coverage. Point and area source work sheets would be used to summarize hydrocarbon sources by major category, Standard Industrial Classification (SIC) number, and pollutant (with a distinction made between point and area sources). Computer processing required coding of data together with identifying information. A plant identification number, plant name and address, county number, SIC number, and Source Classification Code (SCC) number would be recorded. Tabular summaries by major category, SIC, and pollutant would be generated.

Application of the hydrocarbon methodology to the RAPS modeling effort was also discussed. It was suggested that emission rates should be determined for specified short time intervals. The special requirements of the RAPS program are: inclusion of smaller point sources, a hydrocarbon breakdown with corresponding SCC numbers, and hourly emission estimates. Allowance should be made for inclusion of point sources to any degree of refinement required.

No data were collected in this effort. The final report, referenced below, was the end product. Additional information can be obtained from the EPA Project Officer.

Publication

Di Gasbarro, P. and M. Borhstein. Methodology for Inventorying Hydrocarbons. GCA Corporation, Bedford, Massachusetts. Task Order No. 7 Final Report, EPA Contract 68-02-1006. March 1976. EPA-600/4-76-013.

14.1.5 METHODOLOGY FOR LINE SOURCE EMISSIONS

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Funding EPA Contract No. 68-02-1417

Period of Performance January 1974 - January 1975

Summary

The methodology developed by Washington University documented techniques for determining major freeway and arterial roadways considered to be line emission sources in a metropolitan area. In applying these criteria to the St. Louis AQCR, the most recent traffic data were obtained pertaining to traffic volume, vehicle mix and average vehicle speed, with the data collection effort focusing primarily on areas designated as urban or in the process of urbanizing.

All roadways were plotted as links with UTM coordinates and RAPS Grid System numbers, with appropriate traffic data (such as average daily total traffic) being assigned to each link. Emission levels were estimated using the Department of Transportation SAPOLLUT model, which computes emissions and concentrations of CO, NO_x, and HC for a traffic network. A complete data base for freeways, principal arterials, and minor arterials was thus established, along with formulas relating emissions to roadway characteristics. An elaborate software package was developed for retrieval of these data.

The methodology report, referenced below, represents the final product of this research effort. Additional information can be obtained from the EPA Project Officer.

Publication

Haefner, L. E. Methodology for the Determination of Emission Line Sources. Washington University, St. Louis, Missouri. EPA Contract 68-02-1417. February 1975. EPA-450/3-76-035.

14.1.6 LINE AND AREA SOURCE MOTOR VEHICLE METHODOLOGY

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Funding EPA Contract No. 68-02-2060

Period of Performance February 1975 - June 1976

Summary

The previous section, 14.1.5 "Methodology for Line Source Emissions", devised techniques to identify emission line sources. Subsequently this methodology goes further, proposing techniques for estimating SO_2, NO_X, CO, HC, and particulate emissions for each of the line sources identified in the earlier methodology.

In accomplishing this task, data were collected in the St. Louis AQCR on average daily traffic, peak hour traffic, hourly distribution of traffic, percent of heavy duty vehicles, and the peak directional distribution of traffic. Roadways were represented as straight line segments called links drawn in such a way that no links would cross a grid boundary of the RAPS Grid System. The grid was superimposed on a computer plot of roadway links and oriented with respect to UTM coordinates. The roadway links themselves were plotted to trace as closely as possible the actual St. Louis AQCR roadway network.

To describe vehicle operating characteristics, the volume to capacity ratio, peak hour speed by direction, average daily speed, and changes in road capacity were determined wherever possible. Not all types of data were collected for all roadways; however, freeways and major arterials were thoroughly documented.

Empirical formulas were then used with the traffic and operating characteristics data to estimate motor vehicle emissions. All essential data, taken from 1973-1975, have been recorded on magnetic tape and are in the emission inventory data bank at Research Triangle Park. Software is available for use on the Univac 1110 computer for computing line source emissions for any grid square in the St. Louis AQCR for any specified hour of the day or day of the week. Provision was also made for estimation of emissions from so-called "area sources", i.e. sources of smaller magnitude than freeways, major arterials, or minor arterials. Recently the methodology has been expanded to include reentrainment of fugitive dust caused by motor vehicles. Though the raw data were not intended for dissemination, emissions data are readily available. Those interested in obtaining such data should contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

A methodology final report was submitted to the EPA Project Officer for this contract along with ten volumes of uncorrected line source data. At a later date, these data were corrected and augmented by another contractor (Rockwell International Air Monitoring Center, Newbury Park, California) and the results submitted to the EPA Project Officer.

Publication

Haefner, L. E. A Methodology for the Determination of Line and Area Source Emissions from Motor Vehicles for the RAPS Program. Washington University, St. Louis, Missouri. EPA Contract 68-02-2060. June 1976. EPA-450/3-77-019.

14.1.7 AIRPORT EMISSION INVENTORY METHODOLOGY

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Funding

EPA Contract No. 68-02-0041, Task No. 18
Order No. DA-6-99-0950B To Modify

Period of Performance

January - December 1974, extended to December 1975
to update User Manual under Order to Modify

Summary

The airport methodology actually consists of three submethodologies, one each for municipal, civilian, and military airports. Generally speaking, the methods for inventorying each consist of determining the emission rate, location, and duration. The methodologies were applied to airports in the St. Louis AQCR, namely: Lambert-St. Louis International Airport, Scott Air Force Base, and the small civilian airports.

For Lambert Airport a methodology was developed which estimated contributions from aircraft flight operations, ground service vehicles, fuel handling and storage, and engine testing and maintenance. Five parameters were found to be essential: temporal activity patterns, spatial activity patterns, percent volume distribution of aircraft types, time spent in the different operating modes, and emission factors. Appropriate data were

collected to supply those values. Sources and types of data are listed in Table 26 with dates, indicating the base period for the data collection.

Among the areas analyzed in the Scott Air Force Base methodology were aircraft flight activity, emission factors, ground service vehicle operations, fuel handling and storage, and engine testing and maintenance.

Incorporated into the civilian airports methodology was an analytical description of flight activity, spatial detail, emissions from flight activity, ground service vehicles, fuel storage and handling, and engine testing and maintenance. In every case, sufficient data were collected to allow an estimate of emissions to be made.

An airport methodology final report, referenced below, was the end product of this Task Order. It details the procedures developed for calculating emissions. In addition, an airport emission inventory computer program and user's manual were developed. AIRPEM (Airport Emission Inventory Program) was programmed in FORTRAN to compile on a Univac computer with an EXEC 8 FORTRAN V compiler. This software was developed to estimate pollutant emissions from airport traffic data and airport operational information. Emissions are apportioned to the appropriate RAPS grid elements according to flight and flight support activities that occur within each. Full documentation of the software is contained in a user's manual, referenced below.

Those interested in obtaining airport emission estimates for the St. Louis AQCR based on the methodology (hourly temporal resolution, grid square spatial resolution) should contact:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Patterson, R. M., R. D. Wang, and F. A. Record. Airport Emission Inventory Methodology. GCA Corporation, GCA/Technology Division, Bedford, Massachusetts. Task No. 18 Final Report, EPA Contract 68-02-0041. December 1974. EPA-450/3-75-048.

Publications (continued)

Patterson, R. M., R. D. Wang, and F. A. Record. Airport Emission Inventory Program (AIRPEM) User Manual. GCA Corportion, GCA/Technology Division, Bedford, Massachusetts. Task No. 18 Final Report, EPA Contract 68-02-0041. Order No. DA-6-99-0950B. December 1975.

TABLE 26. SOURCES OF AIRPORT METHODOLOGY DATA FOR LAMBERT-ST. LOUIS INTERNATIONAL AIRPORT

NATURE OF DATA	SOURCE	DATE(S)
Air traffic volume	Federal Aviation Administration Air Traffic Control Tower, Jerome C. Moonier, contact (Lambert Field)	1974
Air traffic volume	Official Airline Guide listings. Reuben H. Donnelley Corporation, Oak Brook, Illinois	1972 - 1973
Ground service, maintenance, engine testing activity	Lambert Field, Manager's Office, Arthur K. Muchmore, Assistant Airport Manager, Operations and Maintenance, contact	1974
Aircraft emissions	Bogdan, L., et al. Analysis of Aircraft Exhaust Emission Measurements. Cornell Aeronautical Laboratory, Inc., Buffalo, New York	1971
Fuel consumption	Allied Aviation Fueling, Lambert Field, George Elliot, contact	1974
Emission factors	Compilation of Air Pollutant Emission Factors. 2nd Ed., Environmental Protection Agency. (AP-42)	1973

14.1.8 METHODOLOGY FOR RAILROAD FUEL USE AND EMISSIONS

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Funding EPA Contract No. 68-02-1895, Task Order No. 2

Period of Performance September 1976 - April 1977

Summary

The objective of this study was to develop a methodology for estimating fuel use and emissions from locomotives operating in the St. Louis AQCR and to allocate these estimates to the RAPS area source grid system. Railroad emissions of some pollutants have been estimated to comprise up to ten percent of total area source emissions in AQCR 70 and, in areas of heavy rail activity, can have a significant impact on ambient air quality concentrations.

Separate methodologies were developed for the two major types of rail activity - road or line-haul operation and activity within switch yards. The methodology for road locomotives utilizes a line source concept and synthesizes the rail network by a series of links connecting a system of node points within the study area. The methodology for switch yard operation utilizes an area source concept. Both methodologies use as a basic unit locomotive horsepower-hours and were programmed to provide an analysis of fuel use and emissions for five criteria pollutants on a grid-by-grid basis as well as for the entire study area.

Application of this methodology in the St. Louis AQCR required an inventory of railroad activity. This inventory was supplied by the U. S. Department of Transportation, Transportation Systems Center, and included information on the routing, run time, and locomotive(s) for each train in operation on a typical day in 1973 plus estimates of switchyard and transfer activity. Fuel use and emission factors used in this study are those presented in the Environmental Protection Agency's document, Compilation of Air Pollutant Emission Factors (AP-42).

The fuel report referenced below describes the methodology developed to estimate and allocate rail emissions and presents the results of its application to the St. Louis AQCR. As with many of the models developed for RAPS, this allocation methodology can be easily applied in other areas of the country. For this reason, a manual for coding the necessary input data and examples of the control cards necessary to utilize the software package on the EPA Univac 1110 computer are included.

The emission data are stored in the RAPS data bank and can be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Wiltsee, K.W., S. B. Khanna and J. C. Hanson. Assessment of Railroad Fuel Use and Emissions for the Regional Air Pollution Study. Walden Research, Wilmington, Massachusetts. Task Order No. 2 Final Report, EPA Contract 68-02-1895. April 1977. EPA 450/3-77-025.

14.1.9 METHODOLOGY FOR RIVER TOWBOAT EMISSIONS

Principal Investigator

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Funding

Department of Transportation, Work Unit No. OS 622/R6501 (Part of the Technology for Environmental Analysis Project (PPA-OS-522) of the DOT Environmental Measurements Branch, Transportation Systems Center, Office of the Secretary of Transportation, Washington, D.C.)

Period of Performance March 1974 - February 1976

Summary

This study provides an estimate of river towboat emissions for the St. Louis AQCR. The estimate of emissions was based primarily on river traffic data taken in 1973 and 1974 by the Corps of Engineers at Lock 27 near St. Louis and on exhaust emission factors of similar engines of the Coast Guard fleet and railroad locomotives. The capability for calculation of emissions from affected grid squares within the RAPS Grid System was implemented. Pollutants considered were SO_X, NO_X, CO, THC and particulates. The method used consisted of estimating river traffic and propulsion engine characteristics from limited statistical information on river traffic and from observations by personnel familiar with river vessel operations. The traffic volumes and engine types were then used to calculate emissions based on emissions factors of similar diesel engines. No actual emission testing of towboats was undertaken. Because the volume of river traffic is so low and

the diversity of river vessels so great, hourly emission estimates were deemed unfeasible and daily emission estimates only were considered in the methodology.

The final report, referenced below, contains emission estimates in tabular form in addition to the description of the methodologies used. The emission data are stored in the RAPS Data Bank and can be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Sturn, J. C. An Estimation of River Towboat Air Pollution in St. Louis, Missouri. U. S. Department of Transportation. Feburary 1976. DOT-TSC-OST-75-42.

14.1.10 OFF-HIGHWAY MOBILE SOURCE METHODOLOGY

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Funding EPA Contract No. 68-02-1397

Period of Performance April - October 1974

Summary

Part of the RAPS Emission Inventory program involved developing a methodology for estimating emissions from off-highway mobile sources within the St. Louis AQCR. Initiating the project was a technical literature search to procure emissions, population, and usage data on the following: outboard motors, snowmobiles, motorcycles, lawn and garden equipment, construction equipment, industrial equipment and farm equipment. Sources of data included EPA reports, technical papers, state motor vehicle registration bureaus, and statistical publications. From such sources, data directly and indirectly related to off-highway mobile source emissions were collected.

The only information directly related to emissions was in the form of emission factors, resulting from actual engine tests, giving weight of pollutant emitted per unit of time or distance traveled. Pollutants considered were particulates HC, CO, NO_X, RCHO, SO_X, and for outboards, CO_2.

Formulas were derived for calculating county emissions and emissions at the grid square level for each category of off-highway mobile source. The methods were demonstrated for counties in the St. Louis AQCR. The final report, referenced below, includes emissions from each source type. Additional information can be obtained from the EPA Project Officer.

Publication

Hare, Charles T. Methodology for Estimating Emissions from Off-Highway Mobile Sources for the RAPS Program. Southwest Research Institute, San Antonio, Texas. EPA Contract 68-02-1397. October 1974. EPA-450/3-75-002.

14.1.11 FUGITIVE DUST METHODOLOGY AND EMISSION INVENTORY

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Funding EPA Contract No. 68-02-2040

Period of Performance August - December 1975

Summary

This methodology and emission inventory was developed to identify and quantify the sources of fugitive dust in the St. Louis AQCR. The six categories of fugitive dust sources identified and analyzed were unpaved roads, agricultural tilling, wind erosion of agricultural land, construction sites, aggregate storage piles, and unpaved airstrips. Emission factors for each of these categories were obtained by MRI under EPA Contract No. 68-02-0619 (not part of the RAPS program) and were adjusted to the climatic conditions and surface properties characteristic of the St. Louis area.

Together with appropriate annual measures of the extent of each source type within each RAPS grid element, emission factors were used to estimate grid square emissions. Appropriate measures of source extent, corresponding to the six categories or types mentioned above are: vehicle miles traveled on unpaved roads, acres of land tilled/year, average exposed (unvegetated) acreage, annual acres of construction, quantity of aggregate stored, and airport landing/takeoff cycles. Data were compiled in order to assign a value for each of these quantities for each RAPS grid square. To facilitate this activity an overlay map of the RAPS Grid System incorporating county and

river outlines was prepared and superimposed on land use and street maps of the St. Louis area. Department of Agriculture publications, a climatic atlas, and additional publications of a statistical nature were used with the maps and overlays to provide additional pertinent data.

The result was a computer tabulation of annual fugitive dust emissions for the six source categories for the 1989 grid squares in the St. Louis AQCR. Particle sizes as determined by the emission factors fall within the range of less than 30 μm diameter, the nominal cut-off diameter of a standard high-volume particulate sampler. A Fortran program was devised to temporally apportion emissions to account for variations by hour of the day, day of the week, and season of the year. The computer program along with the calculated annual grid square emission values was submitted on magnetic tape to Rockwell International Air Monitoring Center for processing and entry into the RAPS Data Bank. Submission to the data bank has been completed. A methodology and emission inventory final report, referenced below, represents the final product of this effort. Additional information can be obtained from the EPA Project Officer.

Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Cowherd, C., and C. Guenther. Development of a Methodology and Emission Inventory for Fugitive Dust for the Regional Air Pollution Study. Midwest Research Institute, Kansas City, Missouri. EPA Contract 68-02-2040. January 1976. EPA-450/3-76-003.

14.2 INDIVIDUAL EMISSION INVENTORIES

14.2.1 RAPS PRELIMINARY EMISSION INVENTORY

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Funding EPA Contract No. 68-02-1026

Period of Performance January 1973 - January 1974

Summary

The RAPS preliminary emission inventory required the execution of five subtasks.

Task A. Definition of Potential Users. A survey was made to determine potential users and uses of the RAPS emission inventory. To satisfy the variety of users from modelers to air pollution control agencies, a wide range of spatial and temporal resolution was required. The five criteria pollutants were judged to be the most significant: SO_2, NO_X, CO, HC, and particulates.

Task B. Emission Inventory Content. Analysis of the problems associated with obtaining emissions data with the spatial and temporal resolution required by RAPS was undertaken. Pollutant sources were described, analyzed, and classified according to identity, function, and pollutant emitted. The impossibility of physically testing every source indicated the necessity to develop emission factors. It was recommended that a special high-resolution emission inventory be developed to provide hourly emissions data for SO_2, NO_X, CO, HC, and particulates in the form of weight of pollutant emitted per hour, with source location in UTM coordinates provided to the nearest 0.1 km. The final portion of Task B was a detailed description of procedures for developing the inventory. Types of records used to estimate emissions were classified as follows: a) continuous emissions monitoring records; b) continuous records of fuel consumption, operating, or process data; c) short term, periodic records of fuel consumption, operating, or process data; d) long-term records or estimates of fuel consumption, operating, or process data.

Task C. Emission Inventory File System. In this section, specifications for a data handling system were discussed and the characteristics of an appropriate system described. The proposed system should have these characteristics:

* Data bases of 20 million character size, containing up to 2000 items, each including 10 to 100 data elements, in up to 4 hierarchic levels.
* Batch data entry from punch cards, magnetic tapes, or disk files
* Capability for defining hierarchic data structures, including list components.
* Symbolic naming of data components.
* Unrestricted lengths of lists and records.
* Retrieval of items by content or partial content of any data component, including logical combinations of retrieval specifications.
* Editing and updating individual items or groups of items.
* Interface for external programs to access data items and data components in the files.
* (Optional) Capability of calling special subroutines within the data system for operations requiring recognition of specialized formats within a data component.
* (Optional) Construction of data files in specified formats for use by external programs
* (Optional) Sorting and indexing selected subfiles by content.

The general characteristics of the input and output routines were also defined:

The input subroutine must:

- Access source item via file address;
- Read consumption data component from source item;
- Extract SCC code, unit, time ranges, and consumption values;
- Read emission factor for Source Classification Code (SCC) from Emission Factor File;
- Convert values to the units required by the model.

The output subroutine must:

- Generate calculated emission data element for the pollutant and for the time ranges defined by the model, in the format required by the inventory;
- Append the emission element to the same source item from which the consumption data were read.

Task D. Survey of Existing Emission Data. An historical review of existing emission inventory data for St. Louis indicated that five inventories had been obtained:

IPP Emission Inventory - 1968
IBM Emission Inventory - 1970
DAQED Emission Inventory - 1971
NATO Emission Inventory - 1971
NEDS Emission Inventory - 1973

The characteristics and limitations of these inventories were discussed. Based on the latest National Emission Data System (NEDS) inventory, the characteristic distribution of sources of pollutants were described. For example, the following distribution existed for SO_2 sources:

	NUMBER SOURCES	TONS/YEAR	PERCENT OF POINT SOURCES	PERCENT OF TOTAL
TOTAL AQCR		1,233,805		100.0
ALL POINT SOURCES	358	1,220,897	100.0	98.9
P.S. > 100 T/YR	184	1,182,909	96.9	95.9
P.S. > 1000 T/YR	67	1,144,906	93.8	92.8
P.S. > 5000 T/YR	26	1,060,480	86.8	85.9
P.S. > 10,000 T/YR	13	990,500	81.1	80.3
P.S. > 100,000 T/YR	4	608,000	49.8	49.3
TOTAL AREA SOURCES		12,908		1.1

Based on this information, it became possible to plan on gathering a measured, hourly inventory, since the number of important sources appeared to be limited. In this instance, four sources accounted for about 50% of the emissions, 26 sources for 87%.

Task E. Emission Modeling. An in-depth review of the available literature on emission modeling resulted in the identification of 28 papers and reports deemed significant in the context of the RAPS study. The models were reviewed according to emission type, source mobility, and degree of verification. Significantly, only three of the 28 models had undergone experimental verification.

In the past, emissions data had been collected mainly on an annual basis. Finer temporal resolution was obtained by an aggregation of emission factors, correlations and algorithms. Because of the potential errors inherent in this approach, it was recommended that RAPS rely heavily on measurement techniques. However, the emissions from small stationary sources and from mobile sources would continue to require modeling.

A parametric study of the errors resulting from mislocation of a source or receptor for several atmospheric conditions was performed.

The final report and additional information may be obtained from the EPA Project Officer.

Publication

Littman, F.E., S. Rubin, K.T. Semrau, and W.F. Dabberdt. A Regional Air Pollution Study (RAPS) Preliminary Emission Inventory. Stanford Research Institute, Menlo Park, California. EPA Contract 68-02-1026. January 1974. EPA-450/3-74-030.

14.2.2 POINT SOURCE CRITERIA POLLUTANT EMISSION INVENTORY

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Funding

EPA Contract No. 68-02-1081, Task Order No. 16, Phase II
EPA Contract No. 68-02-1081, Task Order No. 55
EPA Contract No. 68-02-2093, Task Order No. 108A

Periods of Performance

Task Order No. 16, Phase II	July 1974 - June 1975
Task Order No. 55	June - December 1975
Task Order No. 108A	January 1976 - March 1978

Summary

The methodology developed during Phase I of Task Order No. 16 (Section 14.1.2) was implemented under these task orders. Data collection was started in October 1974 with the largest sources of pollution, the power generating stations. By January 1975, data from essentially all major sources were being received and processed, and the acquisition of data from minor sources also had been virtually completed. The general approach was to request from the major sources hourly fuel consumption or related process data, as well as sulfur analyses of the fuel or processed materials. In a few cases, stack gas measurements were available.

Data from the minor sources were based on annual (1975) fuel usage or process data. A distribution pattern was also obtained, which recorded the daily, weekly and annual work distribution. From this pattern the actual number of hours of operation could be determined by the computer program, and average emissions calculated.

As of April 1975, measured hourly data were being obtained on 128 points (stacks) at 19 locations, representing 12 companies. Annual data were obtained from an additional 20 companies, representing 46 points. In addition to fuel consumption, other data were obtained for each source including: UTM coordinates of source, stack height, diameter, flow velocity, temperature, pollution controls and control efficiency.

Detailed coding forms and coding procedures were worked out and are described in the final report.

Data collection was continued under Task Order No. 55. However, the emphasis was shifted from an SO_2 inventory to include all other criteria pollutants. A limited amount of source testing was undertaken to verify emission factors, using EPA Standard Methods 1 - 8. Emission factors determined in this effort were used for the particular sources under consideration.

Task Order No. 108A made possible the continuation of the data collection through 1976. Ultimately, hourly data were recorded for most criteria pollutants from 113 point sources at 22 locations and annual data from about 130 sources at 92 locations. Additional source tests were also carried out.

The RAPS point source data base contains hourly data for criteria pollutants for the St. Louis AQCR (70) for all of 1975 and 1976. The data are stored in the RAPS Data Bank at Research Triangle Park and may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Littman, F. E., and R. W. Griscom. Point Source Emission Inventory. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 16 Phase II Final Report, EPA Contract 68-02-1081. July 1975.

Littman, F. E., R. W. Griscom, and O. Klein. Point Source Emission Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 55 Final Report, EPA Contract 68-02-1081. March 1977. EPA-600/4-77-014.

Littman, F. E. Point Source Methodology and Emission Inventory for the Regional Air Pollution Study. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 198A Completion Report, EPA Contract 68-02-2093. July 1978. EPA-600/4-78-042.

14.2.3 POINT SOURCE NON-CRITERIA POLLUTANT EMISSION INVENTORY

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Funding EPA Contract No. 68-02-1081, Task Order No. 54

Period of Performance April 1975 - January 1976

Summary

An emission inventory of "non-criteria" pollutants, i.e., pollutants other than HC, CO, SO_2, NO_X, or particulates was compiled. The pollutants considered in Task Order No. 54 were:

- arsenic
- asbestos
- barium
- benz-a-pyrene
- beryllium
- boron
- cadmium
- chromium
- copper
- lead
- magnesium
- manganese
- mercury
- molybdenum
- nickel
- phosphorus
- selenium
- silver
- titanium
- vanadium
- zinc

As in other emission inventories, the emissions of a given pollutant were not measured but were estimated from process data using emission factors. The source of process data for the St. Louis AQCR was the RAPS emission inventory data. Emission factors for the 21 non-criteria pollutants were taken from the series of EPA reports entitled National Inventory of Sources and Emissions.

The NEDS classification of industrial processes which produce emissions is called the Source Classification Code (SCC). To each SCC number applicable to the St. Louis AQCR, a corresponding set of non-criteria pollutant emission factors was assigned. These factors were incorporated into the RAPS emission inventory data base, and software developed for computing non-criteria pollutant emissions from the sources in the St. Louis AQCR. Every industrial source is described by one or more SCC codes. Non-criteria pollutant emissions may then be determined by using the associated emission factors with process data. Computing non-criteria pollutant emissions from all stationary industrial sources in the St. Louis AQCR is now a capability of the RAPS data handling system.

Additional information and data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Littman, F. E., H. H. Wang, and J. Piere. Non-Criteria Pollutant Inventory for the St. Louis AQCR. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 54 Final Report, EPA Contract 68-02-1081. April 1977. EPA-600/4-77-018.

14.2.4 POINT SOURCE SULFUR COMPOUND EMISSION INVENTORY

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Funding EPA Contract No. 68-02-1081, Task Order No. 56

Period of Performance May 1975 - April 1976

Summary

This task order deals with SO_3 emissions from stationary point sources. The term "sulfur trioxide" (SO_3) is used, though it is realized that in its particulate form, in which it is customarily collected, the compound is hydrated to sulfuric acid (H_2SO_4).

At combustion sources, both SO_2 and SO_3 originate from the oxidation of sulfur or sulfur containing compounds. A smaller amount comes from process operations such as the roasting of ores, the manufacture of sulfuric acid, etc.

In the presence of excess air in a combustion operation, a fraction of the sulfur dioxide is converted to sulfur trioxide (SO_3) according to:

$$2\ SO_2 + O_2 \rightarrow 2\ SO_3 + 45.2\ \text{Kcal}$$

The reaction is exothermic; however, the reaction rates are negligible below 200°C (392°F), reach a maximum around 400°C (752°F) and taper off to zero at 1000°C (1832°F). Rapid conversion takes place only in the presence of a catalyst. In general, the percentage conversion falls in the range of 0.5 to 5%, with actual concentrations below 50 ppm of SO_3.

Both SO_2 and SO_3 values were determined experimentally at St. Louis. The concentration ranges encountered were well within the range indicated by other investigators. There appeared to be a marked dependence on excess oxygen: the percentage of SO_3 increased with increasing oxygen up to about 9%, then dropped rapidly. There did not seem to be any correlation with the sulfur content of the fuel nor did there appear to be any marked effect of boiler capacity on the amount of concentration of SO_3 produced. The RMS average SO_3 emission appears to be about 1.85% of the SO_2 emission. This factor was incorporated in the data handling system output program, which calculates SO_3 emissions based on the corresponding SO_2 emissions.

Because of some questions about the accuracy of EPA Method 8, a different analytical technique was used, which was first described by Goksøyr and Ross and subsequently verified by Lisle and Sensenbaugh. The method, referred to as the "Shell" method, is based on the condensation of sulfuric acid mist at temperatures below its dew point (but above the dew point of water) in a condenser backed up by a fritted glass filter. The condensate is washed out and titrated.

Data presented in the literature indicate that adsorption of SO_3 is essentially complete, repeatability is excellent, SO_2 in concentrations up to 2000 ppm does not interfere, and a precision of ± 0.3 pp, of SO_3 can be readily attained.

The method was then evaluated in the laboratory. The results of the evaluation indicated an average 100.1 ± 6.5% recovery with no significant interference from any of the variables tested. Detailed data on SO_3 emissions in the St. Louis AQCR may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Littman, F.E., R.W. Griscom, and H.H. Wang. Sulfur Compounds and Particulate Size Distribution Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 56 Final Report, EPA Contract 68-02-1081. April 1977. EPA 600/4-77-017.

14.2.5 POINT SOURCE PARTICULATE SIZE DISTRIBUTION INVENTORY

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Funding EPA Contract No. 68-02-1081, Task Order No. 56

Period of Performance May 1975 - April 1976

Summary

Particulate emissions from point sources in the St. Louis AQCR were broken down into representative particle sizes in the following ranges (in microns):

.01-.05, .05-.1, 1-.5, .5-1, 1-3, 3-7, and > 7.

The breakdown was based on data from characteristic particle size distribution, fractional efficiency of control equipment and average practices for industrial sources, based on Fine Particulate Emission Inventory and Control Surveys (EPA 450/3-74-040). Appropriate factors for emissions, percentage of production capacity on which control equipment was installed, particle size distribution and penetration (1 minus fractional efficiency of control systems) were applied to production rate data. The data were coupled to SCC numbers and are available as an output from the RAPS Data Bank.

In addition, a limited number of source tests were performed using an Anderson Cascade impactor. The individual states were weighed and examined microscopically. In addition to incompletely burned coal particles and

fused glassy and iron oxide particles, copious amounts of ammonium sulfate crystals appeared on most stages. These crystals were apprently formed on the substrates, as most of them were too large to have been deposited on the various stages. Data obtained experimentally were incorporated in the RAPS inventory for the specific sources tested. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Littman, F. E., R. W. Griscom, and H. H. Wang. Sulfur Compounds and Particulate Size Distribution Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 56 Final Report, EPA Contract 68-02-1081. April 1977. EPA 600/4-77-017.

14.2.6 STATIONARY INDUSTRIAL AREA SOURCE EMISSION INVENTORY

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Funding EPA Contract No. 68-02-2093, Task Order No. 108D

Period of Performance February - July 1976

Summary

In the RAPS emission inventory, the category, major stationary point sources, includes all sources which individually contribute more than approximately 0.1% of the total emissions of a given pollutant in the AQCR. Minor sources, for which less detailed data are available, are those emitting more than 0.01% of a given pollutant. All remaining emissions are included in area source emissions. These include industrial area sources as well as residential and commercial area sources.

All area emission sources were assigned to a system of grid squares developed for RAPS which divides the AQCR into squares from 1 to 100 km^2. Generally, the allocation to grid squares was based on readily available parameters. For example, emissions from residential and commercial sources were assigned to the grid squares on a population density basis. The distribution of industrial area sources on the micro scale of grid squares does not correlate with any available parameter, although on a larger scale industrial employment has been used successfully. Thus, the only available techniques consisted in an actual count of the sources, coupled with deter-

minations of their exact locations (in UTM coordinates), estimates of their annual fuel consumption or process rates and work patterns. Some 55 companies were included in this classification.

All the data for 1975 and 1976 were analyzed, put on coding forms, keypunched, and entered into the RAPS emission inventory data base. Parameters determined were: location in UTM coordinates, stack height, stack diameter, flow velocity, temperature, control efficiency (if controls were present), plant operating schedule or process schedule.

Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Littman, F.E., and K.M. Isam. Stationary Industrial Area Source Emission Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108D Completion Report, EPA Contract 68-02-2093. July 1976.

14.2.7 OFF-HIGHWAY MOBILE SOURCE EMISSION INVENTORY

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Funding EPA Contract No. 68-02-2093, Task Order No. 108E

Period of Performance March - December 1976.

Summary

The purpose of the off-highway mobile source emission inventory was to calculate emissions for the Metropolitan St. Louis AQCR of a variety of unregulated sources with a spatial resolution corresponding to grid elements. Six equipment categories were dealt with: motorcycles, lawn and garden equipment, construction equipment, industrial equipment, farm equipment, and outboard motorboats.

Annual emission totals of the several off-highway mobile source types were temporally distributed over the year to reflect diurnal and seasonal variation of usage. To accomplish this, each equipment category was assigned an annual operation pattern which most closely approximated real-life use during a calendar year. The operating patterns assumed were as follows:

1.	Off-highway motorcycles	March through October	9 AM - 7 PM
2.	Lawn and garden equipment	April through September	9 AM - 7 PM
3.	Construction equipment	March through October	6 AM - 6 PM
4.	Industrial equipment	Year round	8 AM - 6 PM
5.	Farm equipment	March through October	5 AM - 7 PM
6.	Outboard motors	April through September	9 AM - 7 PM

A Fortran program was prepared in order to compute emissions from the nearly 2,000 grid squares for each of the six equipment types. Sample calculations for each category were made to show the magnitude of emissions from off-highway mobile sources.

The procedures involved in arriving at grid element emission values were described in detail with all deviations from the recommended methodology noted and explained. Because of the nature of existing data this inventory indicates only an order of magnitude of emissions at the grid level.

Additional information may be obtained from the EPA Task Coordinator. Data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Littman, F.E., and K. M. Isam. Off-Highway Mobile Source Emission Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108E Completion Report, EPA Contract 68-02-2093. October 1977. EPA-600/4-77-041.

14.2.8 HYDROCARBON EMISSION INVENTORY

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Funding EPA Contract No. 68-02-2093, Task No. 108F

Period of Performance April 1976 - March 1977

Summary

The hydrocarbon emission inventory included all stationary point sources in the St. Louis AQCR emitting more than one ton per year of total hydrocarbons. Point source emissions were considered to be those released through a stack or vent. For fuel combustion sources data were hourly, and for all others data were annual. Data were also obtained on evaporative emissions of hydrocarbons. In all cases data were obtained by contacting the companies in the St. Louis AQCR which were emitting hydrocarbons. Data included surface coating and solvent production and usage, refinery throughputs, and petroleum storage capacities. A sensitivity analysis was applied to these data to evaluate their accuracy.

As part of the hydrocarbon inventory a methodology was developed for separating the total hydrocarbon emissions into methane and non-methane components using the SCC code. In addition, a method was developed to analyze stack samples for methane and total hydrocarbons at expected stack concentrations (1 ppm to 10^6 ppm). Actual stack sampling was performed at three sites and is reported in the publication cited below. The results of this

study were incorporated in the Point and Area Source Organic Emission Inventory (Section 14.2.9).

Addtional information may be obtained from the EPA Task Coordinator. Data may be obtained by contacting:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Littman, F.E., R.W. Griscom, and G. Seeger. Hydrocarbon Emission Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108F Completion Report, EPA Contract No. 68-02-2093. March 1977.

14.2.9 POINT AND AREA SOURCE ORGANIC EMISSION INVENTORY

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Funding EPA Contract No. 68-02-2093, Task Order No. 108I

Period of Performance February 1976 - June 1977

Summary

Hydrocarbon emissions in the St. Louis AQCR originate from many different sources. Emissions have been discussed in the following inventories:

Hydrocarbon Emission Inventory	EPA Contract No. 68-02-2093, Task Order No. 108F
Residential and Commercial Area Source Inventory	EPA 450/2-75-078
Stationary Industrial Area Sources	EPA Contract No. 68-02-2093, Task Order No. 108D
Line and Area Source Motor Vehicle Emissions	EPA 450/3-77-019
River Tow Boat Emissions	DOT-TSC-OST-75-42
Airport Emission Inventory	EPA 450/3-75-048
Emissions from Rail Operations	EPA 450/3-77-025
Off-Highway Mobile Sources	EPA Contract No. 68-02-2093, Task Order No. 108E

The RAPS point and area source hydrocarbon inventory was designed to provide emissions data for the evaluations of photochemical reaction models. As the reactivity of organics varies widely, it was important to determine not only the amount emitted, but also the compositions.

Chemical kinetic mechanisms present in air quality simulation models require some form of hydrocarbon classification in order to treat the reaction processes and rates associated with their structural make-up. One such classification scheme required in using a lumped chemical kinetic reaction mechanism approach distributes hydrocarbons in the atmosphere structurally into paraffin, olefin, aromatic, aldehyde, and non-reactive classes. This report describes how this classification has been determined for hydrocarbon emissions in the St. Louis AQCR and provides sufficient reference data to derive alternative schemes as required.

In order to make a breakdown of hydrocarbon emissions according to chemical structure, an appropriate compositional analysis was applied to each category of emissions within the available total hydrocarbon inventory. Much of the information was based on analyses performed by J. C. Trijonis and R. W. Arledge in Los Angeles. Since most of the source types exist both in Los Angeles and St. Louis, Trijonis' report was useful in classifying RAPS data. The tabulations were reorganized by rearranging the chemical compounds into the broader classes of paraffins, olefins, aromatics, aldehydes and non-reactives. The composition of petroleum products in the St. Louis area was ascertained and adjustments were made in the tabulation of emissions arising from refinery operations, evaporative losses and automotive exhaust. Emissions from coal combustion and coke ovens were investigated and the results incorporated in the completion report.

The organic emissions inventory data are included in the RAPS data base stored on the Univac 1110 computer at Research Triangle Park. Additional information and data may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Griscom, R.W. Point and Area Source Organic Emission Inventory. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108I Completion Report, EPA Contract 68-02-2093. June 1978. EPA-600/4-78-028.

14.2.10 POINT AND AREA SOURCE HEAT EMISSION INVENTORY

Principal Investigator	Task Coordinator
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Funding

EPA Contract No. 68-02-1081, Task Order No. 38
EPA Contract No. 68-02-2093, Task Order No. 108G

Periods of Performance

Task Order No. 38	October 1974 - January 1976
Task Order No. 108G	June 1976 - October 1977

Summary

As part of the St. Louis Regional Air Pollution Study (RAPS), a heat emission inventory was assembled. Heat emissions to the atmosphere originate, directly or indirectly, from the combustion of fossil fuels.

The determination of point source heat emissions involved the development of appropriate heat emission factors and the methodology for coding and entering these factors into the RAPS emission data bank. Heat emissions factors were applied to fuel consumption or material throughput data.

By far the major portion of heat is released in the atmosphere from area sources. Area heat emissions fall into three broad categories:

1) Heat emissions from the burning of fuel in stationary installations (e.g., space heating).

2) Heat emissions from the consumption of electric power, all of which eventually show up as heat.

3) Heat emissions from burning of fuel in mobile sources (e.g., cars, trucks, rail and airport operations).

Heat emissions from stationary sources consist of several groups: residential heating, commercial heating and industrial heat emissions. Emissions were calculated on the basis of fuel consumption and heat content of the fuels in the various categories.

The breakdown of electric power consumption is approximately 35% residential, 10% commercial, and 55% industrial. The heat emissions resulting from this category are second only to the heat produced by the burning of natural and bottled gas.

Mobile heat sources comprise several categories. By far the largest are highway vehicles which consume well over a billion gallons of gasoline and diesel fuel, giving off an amount of heat almost as large as that given off by space heating (about 32 percent of all area heat emissions).

Railroads, vessels and off-highway mobile equipment contribute two percent, one percent and one percent of all area sources, respectively. Heat emission data have been deposited in the RAPS data base and may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Littman, F.E., and R.W. Griscom. Methodology for a Heat Emission Inventory for the St. Louis AQCR. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 38 Final Report, EPA Contract 68-02-1081. February 1976.

Littman, F.E., R.W. Griscom, and E. Puronen. Heat Emission Inventory for the St. Louis AQCR. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108G Completion Report, EPA Contract 68-02-2093. June 1978. EPA-600/4-78-029.

14.3 DATA HANDLING AND VERIFICATION

14.3.1 THE RAPS GRID SYSTEM

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Funding EPA Purchase Order No. DA-6-99-1202J

Period of Performance February 1974 - December 1975

Summary

The transport and dispersion models generally use point sources directly. Area sources must be described in some manner which approximates point sources for the models to operate with reasonable precision. Area sources, however, include the more ubiquitous, individually small sources which cannot be specifically located.

Basic data for the determination of area source emissions seldom, if ever, are available for geographic or political units or areas smaller than counties. The geographic size of a county, however, is too large for practical use in simulation models for AQCRs. Further constraints imposed by the simulation models require areas to be squares, although they need not be of uniform size. Various criteria have been proposed as bases for selecting the sizes and distribution of the emission area squares. Urbanization, land use, housing counts, and population have all been used to divide AQCRs into grid squares. Essentially,

this results in apportioning county total emissions to grid squares according to estimates of the distribution of population. Since air pollution derives from human activities, this procedure provides a reasonable approach to developing area source emission distributions.

In order to accomplish the objective of the distribution of emissions in a representative way, two separate tasks must be performed: the area must be divided into squares which allow a reasonable precision and efficiency in modeling, and the area source emissions must be distributed among the resulting grid squares. For RAPS, a gridding system was designed based on Universal Transverse Mercator (UTM) coordinates.

The dividing line between UTM Zone 15 and 16 cuts through the eastern portion of the RAPS study area. It was decided to grid the entire area using UTM Zone 15 as the primary zone and extending it into Zone 16 whenever necessary. The latest census data were used in constructing a grid in which each square contained as nearly as possible a constant population count, as long as the minimum grid square size was one square kilometer. Census data were available by census enumeration district along with the geographic coordinates of the center of each district. The Computer-Assisted Area Source Emissions (CAASE) gridding procedure was used which utilizes a series of computer programs and manual procedures to expedite the gridding process. The final report contains a listing of the 1,989 grid squares in tabular and graphic form. Additional information may be obtained from the EPA Project Officer.

Publication

Haws, R.C., R.E. Paddock, and C.E. Masser. The RAPS Grid system. Research Triangle Institute, Research Triangle Park, North Carolina. EPA Purchase Order No. 6-99-1202J. December 1975. EPA 450/3-76-021.

14.3.2 EMISSION INVENTORY PRECISION ANALYSIS

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Funding EPA Contract No. 68-02-1081, Task Order No. 39

Period of Performance May 1974 - November 1975

Summary

As part of the St. Louis Regional Air Pollution Study (RAPS), the emissions data gathered under various task orders were to be evaluated by subjecting them to a precision and weighted sensitivity analysis. A precision analysis is a methodology which evaluates the cumulative errors which are associated with the various steps of assembling an emission inventory, and provides a statistical expression of its total probable error. The weighted sensitivity analysis is a method to define the necessary limits of accuracy for emission values obtained from sources of widely varying sizes in such a manner as to maintain a desired overall accuracy for the whole inventory. Both methodologies were developed in conjunction with the National Emission Data System (NEDS), a uniform classification system developed by the National Air Data Branch to store nationwide emission inventory data. However, neither the weighted sensitivity analysis, nor the precision analysis became operational on the EPA computers by May 1975, and at the direction of the EPA Task Coordinator the task order was terminated.

Additional information concerning this effort may be obtained from the EPA Task Coordinator.

Publication

Littman, F.E., and R.W. Griscom. Emission Inventory Precision Analysis. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 39 Final Report, EPA Contract 68-02-1081. September 1976.

14.3.3 EMISSION INVENTORY DATA HANDLING SYSTEM

Principal Investigator	Task Coordinator
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(314) 567-6722	(919) 541-5285

Funding EPA Contract No. 68-02-1081, Task Order No. 20

Period of Performance April 1974 - December 1975

Summary

The emission inventory data handling system was designed to accommodate the emission data from point, line and area sources which were collected as a part of the basic RAPS study.

Designed to provide maximum feasibility, no actual emissions data are recorded and stored (with few exceptions). Instead, the files contain fuel consumption or process data, which are converted to mass emissions by appropriate manipulation as part of the output program. Consequently, new or additional emission factors can be added without disturbing the data base. The system was conceived to edit, input and update the collected data independent of the time interval, method, data types or units and provide emissions data on an hourly basis thus yielding an emission inventory with the highest resolution of its kind.

An input format for hourly point source data was developed. Data can be punched on cards, tapes, and/or disk for input to the editing program. The editor designed to provide a syntactically flagged error listing detecting illegal syntax and improper limits prior to input. The user has the option of

selecting card, disk or tape input formatted as card images. Data management is handled by System 2000, a general data base management system providing a comprehensive set of data base management features. Users of the RAPS point source data base interact with the data base through Fortran programs that minimize input errors and reduce the parametric qualifications necessary to retrieve a specific subset of data. Several standard output listings are available. These include:

1. A point source listing which will spatiotemporally isolate specific subsets of data ranging from a single point source to the entire AQCR 70 in specified time increments.
2. A summary point source listing which is an annual emissions report for the total AQCR.
3. A modeler's tape program which allows the user to specify a particular subset of hourly stack emissions data for direct input to various modeling programs.

The final report for this task order is no longer representative of the data handling system. Both the Univac 1110 and System 2000 have undergone major system upgrades that have affected the data handling system while the data handling system itself has been modified and expanded.

Efforts to complete the total data handling system under Task Order No. 20 were continued under Task Order No. 108C (Section 14.3.4).

Publication

Piere, J. RAPS Point Source Emission Inventory Data Handling System, User's Manual. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 20 Final Report, EPA Contract 68-02-1081. December 1976.

14.3.4 EMISSION INVENTORY DATA HANDLING SYSTEM ENHANCEMENT

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-2093, Task Order No. 108C

Period of Performance January 1976 - October 1978

Summary

The basic format and structure of the RAPS data handling system were designed under Task Order No. 20 (Section 14.3.3). Task Order No. 108C was concerned with the implementation of the design; that is, the creation of the data base containing the RAPS emission inventory. The data base ultimately grew to contain over 23 million characters and contains the following inventories:

1) Point Source Inventory
2) Organic Emission Inventory
3) Non-Criteria Pollutant Inventory
4) Sulfur Compound (SO_3) Inventory
5) Particulate Size Distribution Inventory
6) Residential and Commercial Emission Inventory
7) Motor Vehicle Emission Inventory
8) Fugitive Dust Emission Inventory
9) River Towboat Emissions
10) Airport Emissions

11) Rail Operations
12) Off-Highway Mobile Sources
13) Point and Area Heat Emission Inventory

The point source data base was developed first. Owing to its size (over 11 million characters) and the frequent interruptions of the operation of the Univac 1110 computer (owing both to mechanical failures and system updates), the loading of the point source data base was not completed until March 1977.

Because of its diversity, the area source data base presented an even bigger challenge. The annual data of which it is composed appeared in a large variety of forms, from tabular data to complex computer programs. Some were ready for incorporation into the RAPS data base. Many required modifications, and some virtually had to be rewritten. All the inventories are now operational on the Univac 1110 computer. Additional information may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Piere, J. RAPS Emission Inventory Data Handling System. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108C Completion Report, EPA Contract 68-02-2093. In preparation.

14.3.5 EMISSION INVENTORY HANDBOOK

Principal Investigator

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Task Coordinator

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Funding

EPA Contract No. 68-02-1081, Task Order No. 37
EPA Contract No. 68-02-2093, Task Order No. 108H

Periods of Performance

Task Order No. 37	July 1974 - August 1975
Task Order No. 108H	September 1976 - April 1977

Summary

The emission inventory assembled for the Regional Air Pollution Study (RAPS) in St. Louis was planned to provide more detailed information than has been available anywhere in the past. Emissions data were collected for a base period of two years (1975 and 1976) based insofar as possible on measured values, commensurate in detail and accuracy with data on ambient concentrations gathered by the Regional Air Monitoring Station (RAMS) network. In order to make the experience gained in this endeavor available for possible future studies, complete documentation of all efforts connected with the collection of the emission inventory was assembled in the Handbook.

The five volume Handbook consists of seven sections: Introduction, An Overview of the Regional Air Pollution Study, Scope of the RAPS Inventory,

Point Source Emissions, Area Source Emissions, RAPS Emission Inventory Data Handling System, and Evaluation and Validation of RAPS Emission Models. A total of 25 reports are presently included. The looseleaf format makes the inclusion of additional reports possible.

The handbook was originally prepared under Task Order No. 37, then revised and updated under Task Order No. 108H. Additional information may be obtained from the EPA Task Coordinator.

Publication

Littman, F.E. RAPS Emission Inventory Handbook (Second Edition). Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108H Completion Report, EPA Contract 68-02-2093. April 1977.

14.3.6 CRITERIA AND NON-CRITERIA POLLUTANT SOURCE TESTING PROGRAM

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-2093, Task Order No. 108B

Period of Performance January 1976 - August 1977

Summary

In order to improve the accuracy of the emission inventory gathered at St. Louis, a number of representative sources were sampled and their stack effluents analyzed. An attempt was made to encompass a wide variety of the larger point sources: large and medium sized power plants burning coal, fuel oil and gas; industrial boilers of different types and sizes; and industrial operations, such as catalyst recovery units in a petroleum refinery, and cement kilns, known or suspected of being major sources of pollution.

In general, the test methods specified in the Appendix of Part 60, CFR Title 40, Standards of Performance for New Stationary Sources were used. The methods include:

Method 1 - Sample and Velocity Traverses
2 - Determination of Stack Gas Velocity
3 - Gas Analysis of CO_2, Excess Air and Dry Molecular Weight
4 - Determination of Moisture in Stack Gases
5 - Determination of Particulate Emissions

6 - Determination of SO_2 Emissions
7 - Determination of Nitrogen Oxide Emissions
8 - Determination of Sulfuric Acid Mist Emissions

Serious problems were encountered with stack gas velocity measurements using Method 2. Using mass balance methods as a check, it became apparent that the values obtained with an S-type Pitot tube, used in accordance with Method 2, were high by amounts ranging from 8 to 78 percent. It appeared that the source of errors was due to cyclonic flow, unfortunately a fairly common occurrence in power plant stacks, where "double entry" stacks (two boilers feeding one stack) are frequently used. For this reason, calculated flow rates were used whenever there was an indication of non-linear flow in the stack, as indicated by the fact that turning the Pitot tube 90° on axis did not give a zero reading on the manometer.

An alternate method was used for determining sulfuric acid mist. The current standard method for SO_3 in stack gases is EPA Method 8 (CFR 40, 60.85, Appendix-Test Methods). Since there was some reason to doubt the accuracy of this method, a different technique was used, which was first described by Goksøyr and Ross and subsequently verified by Lisle and Sensenbaugh. The method is generally referred to as the Shell method, as it was developed in their laboratories. It is based on the condensation of sulfuric acid mist at temperatures below its dew point (but above the dew point of the water) in a condenser backed up by a fritted glass filter. The condensate is washed out and titrated. Data presented in the literature indicate that adsorption of SO_3 is essentially complete, repeatability is excellent, SO_2 in concentrations up to 2000 ppm does not interfere, and a precision of $\pm$ 0.3 ppm of SO_3 can be readily attained.

The method was then evaluated in the laboratory. The results of the evaluation indicate an average 100.1 $\pm$ 6.5% recovery with no significant interference from any of the variables tested.

Particle size testing was performed with an Andersen Stack Sampling head coupled with the apparatus used for the standard EPA method for particulates. The Andersen is a fractionating inertial impactor which separates particles according to aerodynamic characteristics.

Using the most reliable available results, experimental emission factors were calculated for SO_2, NO_X, CO, HC, and particulates for the sources tested. These emission factors were used in the RAPS inventory for the specific sources tested.

The RMS average SO_3 emission was determined to be about 1.85% of the SO_2 emission. This factor can be used to calculate SO_3 emissions for the area. Results of the particle size tests were also included in the RAPS data bank. Most tests indicated a bimodal distribution, with peaks at 3-7 microns and at less than 1 micron.

Copies of the report containing test results as well as additional information may be obtained by contacting the EPA Task Coordinator.

Publication

Littman, F.E., R.W. Griscom, and O. Klein. Criteria and Non-Criteria Pollutant Source Testing Program. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108B Completion Report, EPA Contract 68-02-2093. November 1977. EPA-600/4-77-044.

14.3.7 EMISSION INVENTORY SUMMARIZATION

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Funding EPA Contract No. 68-02-2093, Task Order No. 108J

Period of Performance August 1977 - June 1978

Summary

This task order summarized the emission inventory aspects of the Regional Air Pollution Study (RAPS). The goal of the emission inventory for the RAPS at St. Louis was an ambitious one: to produce a high resolution inventory for AQCR 70 for all pollutants of interest, to match the ambient data produced by the Regional Air Monitoring Stations (RAMS). The following inventories were collected for the St. Louis area:

A. Point Sources

1) Criteria Pollutants - TSP, SO_x, NO_x, THC, CO
2) Hydrocarbon Breakdown
3) Non-Criteria Pollutants
4) Heat
5) Sulfur Trioxide
6) Particulate Size Distribution

B. Area Sources

1) Criteria Pollutants - TSP, SO_x, NO_x, THC, CO
2) Hydrocarbon Breakdown
3) Heat

The final report discusses the historical background and overall goals of the RAPS study, and describes the individual inventories in some detail. The contribution of each type of pollutant source is summarized and sample printouts of the available outputs are given.

Two formal presentations of the emission inventory summarization were made at Durham and Research Triangle Park to acquaint potential users with the scope and variety of available information.

As part of the task order all available raw and formatted data were gathered, organized by type and source, boxed and shipped to the data manager's office at Research Triangle Park. Additional information may be obtained from the EPA Task Coordinator.

Publication

Littman, F.E. Emission Inventory Summarization. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 108J Completion Report, EPA Contract 68-02-2093. January 1979. EPA-600/4-79-004.

14.3.8 EMISSION INVENTORY QUALITY ASSURANCE PROGRAM

Principal Investigator	Task Coordinators
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Rockwell International	Robert H. Browning (MD-80)
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Funding EPA Contract No. 68-02-2093, Task Order No. 129

Period of Performance September 1977 - June 1978

Summary

During the past four years, efforts have been continuously expended under various task orders in the formation of a RAPS emissions inventory for the St. Louis AQCR. Since the RAPS modelers are using these data in the verification of regional and urban models, it is imperative that the accuracy of the various component inventories be established.

The purpose of this task order was to perform an extensive quality assurance program on the emissions data. Quality assurance of the point, line and area source emission inventories were determined independently of one another. System 2000 immediate access, procedural language programs and Calcomp plots were the primary tools used to provide data for review.

The following aspects of the inventories were examined:

1) Point Source Emission Inventory Raw Data
2) Point Source Software
3) Area Source Emission Inventory Raw Data
4) Area Source Software

5) Line Source Emission Inventory Raw Data
6) Line Source Software
7) Data Continuity, Gaps and Duplication
8) Trace Emission Factors and Software
9) Particulate Size Distribution Coefficients and Software
10) Organic Emission Inventory Coefficients and Software
11) Heat Emission Factors and Software

In addition to the review of the inventories, the methodology subsystems (airports, line and area mobile sources, etc.) were also checked.

The reviews included, for example, individual verification of all stack parameters, such as UTM coordinates, zone and grid numbers, stack height, boiler capacity, diameter, gas exit rate and temperature.

For ten selected sources, process data for a specific day were checked, and hourly emissions were hand calculated and compared with computer data. Hourly, weekday/weekend and seasonal variations were verified, and annual retrieval programs were run.

The following inventories, which form part of the area source emission inventory, were subjected to raw data and software checks:

Airports
Fugitive Dust
Highways
Off-Highway Mobile
Railroads
River Vessels
Stationary Industrial
Stationary Commercial and Residential

Any errors found in the course of this investigation were corrected. Descriptions of input data checks, all test runs, hand calculations, comparisons and documentation of methodology modifications were submitted on status sheets to the EPA Task Coordinators. These status sheets were accepted in lieu of a formal final report.

Publication

Task Order final report not required.

15.0 DATA MANAGEMENT

Introduction

With the massive quantities of data being collected by the Regional Air Monitoring System (RAMS), the Upper Air Sounding Network (UASN) and the variety of data from the Field Expeditionary and Emission Inventory programs, a comprehensive data management effort was essential. Linking the model development and field measurement program to insure the interaction between field oriented activities and data utilization, the objectives of data management were to develop and maintain a data bank responsive to user requirements. Simultaneously data integrity had to be maximized and the impact on computer resources minimized. These requirements led to the development of efficient storage and retrieval software, simple on-line display and analysis capabilities, timely distribution of data in user specified formats, periodic data base summary reports and adaptability to changing needs and schedules.

The RAPS data have been stored on the Univac 1110 computer system at the EPA's Environmental Research Center in Research Triangle Park, North Carolina. The emissions data are stored using MRI Systems Corporation's System 2000 data base management package. All other RAPS data are stored on sequential tape archives. The individual responsible for the incorporation of the RAPS data into the bank and its dissemination is:

RAPS Data Manager
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Browning, R. H. Regional Air Pollution Study (RAPS): Description and Status of the Data Measurements, Quality Assurance and Data Base Management Systems. Presented at NATO/CCMS Meeting, Durham, North Carolina. September 1976.

15.1 RAPS DATA BANK

15.1.1 COMPUTER GRAPHICS PLANNING

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Funding EPA Contract No. 68-02-1081, Task Order No. 10

Period of Performance September - December 1973

Summary

With the large amount of data being collected by RAPS, computer graphics appeared to be the natural display media. Graphics would provide quick and understandable visualization of the data, models and results. To develop a comprehensive graphics capability for application to the RAPS data base, Task Order No. 10, Computer Graphics Planning was initiated.

The study examined RAPS data base objectives for interactive and interpretive display requirements. Existing EPA and contractor computer graphics facilities were evaluated and a basic graphics hardware plan was recommended. This plan utilized existing hardware, specifically, the Univac 1110, Calcomp 900/1136, Univac 9200II data stations, Tektronix 4010 terminals, 4610 hard-copy units and the RAPS PDP 11-40 minicomputer with printer/plotter located at Research Triangle Park. Additional equipment recommended included an audiotape recorder, a digitizing tablet with interfaces, a movie camera with accessories, a Tektronix 4014 large screen terminal, 1200 bps coupler and a video tape recorder. A graphics software package plan to meet RAPS requirements was also devised. Fortran was identified as the primary software language. Calcomp and Tektronix software was designated as the RAPS standard. Tektronix Terminal Control System with Advanced Graphing II software would also be used. Existing EPA graphics programs would be utilized with additional software development to provide the planned graphics capabilities. Finally, test programs using assumed data were developed and displays generated for limited demonstrations.

The final product was a two-volume report which included equipment specification sheets and sample graphics. Copies of the report and additional information regarding this effort may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Allen, A.H. Computer Graphics Planning and Support. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 10 Final Report, EPA Contract 68-02-1081. December 1973.

15.1.2 COMPUTER GRAPHICS INTERFACE

Principal Investigator

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Funding EPA Contract No. 68-02-1081, Task Order No. 13

Period of Performance January - February 1974

Summary

The RAPS Data Base and Graphics Interface Plan was a sequel to the RAPS Computer Graphics Planning task order. The objectives were to evaluate the impact of the graphics package on the RAPS data base, define the data base attributes and develop a plan for an interface capability between the graphics system and the data base. Consequently, the report identifies and discusses key functions of the RAPS data base and graphics system and the interfaces between the functions.

The primary users of the graphics system were identified as the RAPS scientists for data summary, analysis and modeling. Other scientists, programmers and administrators would also use the system. Applications of the system would include the recording and summary of data, demonstration, recalling data, analysis, modeling, forecasting and reporting of results.

The user would obtain information from the system through a standard command language consisting of four character mnemonic codes with complete command descriptions and prompting available for unfamiliar users. System

2000 and Data Management System 1100 were discussed as the likely data management languages for the data management routines. The available Univac 1100 language interfaces were also referenced. The standard Fortran calling procedure, parameters and COMMON were recommended for the command routine and data management routine interface. The steps required for interfacing graphics routines from Tektronix were summarized and the size of the computer program RAPS was estimated.

Other considerations in the report included scan digitizers, digitizing tablets, video tape, a minicomputer bit evaluation method, visits to graphics specialists, data storage and other EPA data sources and data projects.

Copies of the final report and additional information may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Allen, R.H. Plan for Interface between Graphics Display and RAPS Data Base. Rockwell International Air Monitoring Center, Newbury Park, California. Task Order No. 13 Final Report, EPA Contract 68-02-1081. February 1974.

15.1.3 COMPUTER GRAPHICS DEVELOPMENT

Principal Investigator	Task Coordinators
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Funding EPA Contract No. 68-02-1081, Task Order No. 22

Period of Performance March 1974 - May 1976

Summary

Supplementing Task Orders No. 10 and 13, Task Order No. 22 was to develop a comprehensive computer graphics capability for application to the RAPS data base. Working from plans devised in those earlier task orders, the objectives of this task order were to prepare and submit a detailed design and implementation plan for the RAPS graphics system, develop the graphics software, and implement the graphics system on the Univac 1110 at Research Triangle Park.

Although the detailed design and implementation plan was never submitted, a basic graphics software package was developed and partially implemented at Research Triangle Park. The task order was terminated and efforts were completed with enhancements under another contract.

The final report (Users' Manual) included sample interactions with the program and sample graphics. Copies of the report and additional information may be obtained by contacting the EPA Task Coordinator, Robert B. Jurgens.

Publication

Merritt, M.J. RAPS Graphics, A User Oriented Interactive Graphic Language Users' Manual. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 22 Final Report, EPA Contract 68-02-1081. July 1976.

15.1.4 COMPUTER GRAPHICS SYSTEM IMPLEMENTATION

Principal Investigator	Project Officer
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Funding EPA Contract No. 68-02-2379

Period of Performance May 1976 - September 1977

Summary

Completing Task Order No. 22, the features of the RAPS Basic Graphics Package (RBGP) were reviewed and tested. Modifications correcting RBGP making its capabilities operational were performed. Documentation was prepared and the User's Manual was updated and corrected. Software was also developed to provide additional graphics system enhancements.

Copies of the final report and additional information may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Science Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Allen, R. H. Final Report for EPA Graphics Activities. Comp-Aid, Incorporated, Research Triangle Park, North Carolina. EPA Contract 68-02-2379. September 1977.

15.2 RAPS CENTRAL COMPUTER FACILITY

15.2.1 RAMS FIELD SUPPORT ACTIVITIES

Principal Investigator	Task Coordinator
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Funding EPA Contract No. 68-02-1081, Task Order No. 40

Period of Performance May 1974 - June 1975

Summary

Data processing field support at the RAMS Central Computer Facility was an integral part of the RAPS program. Software was generated to verify and optimize the quality and quantity of data collected during the experimental programs.

Software developed as part of this task order included programs to read, edit and verify the gas chromatography lab data cards (Section 7.2.1) as well as generate printed summaries and magnetic tape files. Software for the digitizer allowed the flexible input of coordinate data and control characters with an option for plotting by the Gould plotter for confirmation. One program decoded and listed the Penn State aircraft's data acquisition system tapes for evaluation (Sections 6.1.2.1 and 6.2.1.4). The need for the East-West Gateway Coordinating Council to convert seven track 200 bpi magnetic tapes to multifile nine track 800 bpi tapes provided the impetus to devise a general purpose program whereby seven track tapes of any parity and density could be converted to nine track with any desired parity and density.

The final report included several sample printouts. Copies of the report and additional information may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publication

Taterka, M.H. RAMS Field Support Activities. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 40 Final Report, EPA Contract 68-02-1081. January 1976.

15.2.2 HELICOPTER DATA TRANSLATION AND VERIFICATION

Principal Investigator

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Task Coordinator

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Funding EPA Contract No. 68-02-1081, Task Order No. 45

Period of Performance June 1974 - August 1975

Summary

The helicopter sampling program was a substantial part of the RAPS experimental program (Section 5.0). The flight patterns and the data were intended to provide a vertical extension of the RAMS network. The scope of this task order was to develop the required data processing procedures and software to process these helicopter data.

The primary component of the software package developed consisted of the calibration and editing of the level 1 data resulting in a data printout and a level 2 magnetic tape for the RAPS data bank. In addition to these programs, the package included several plotting programs which produced statistical plots, profile plots, and pattern plots from the data recorded on the level 2 magnetic tape. A set of these programs comprised a batch stream which was used for the initial processing of a data tape. Additional individual programs were created for any specially requested plotting.

The product of this effort included a final report and a data processing manual containing the software and supporting documentation. Copies of the

report and manual as well as additional information may be obtained from:

RAPS Data Manager (MD-80)
Environmental Protection Agency
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

(919) 541-4545

Publications

Taterka, M.H. Helicopter Data Translation and Verification. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 45 Final Report, EPA Contract 68-02-1081. December 1975.

Taterka, M.H. Regional Air Pollution Study Data Processing Manual, Helicopter Data Translation and Verification. Rockwell International Air Monitoring Center, Creve Coeur, Missouri. Task Order No. 45 Data Processing Manual, EPA Contract 68-02-1081. December 1975.

15.2.3 RAMS/RAPS FIELD DATA PROCESSING

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Funding EPA Contract No. 68-02-2093, Task Order No. 107

Period of Performance December 1975 - May 1978

Summary

Field data processing at the RAPS Central Computer Facility included both RAMS data processing and computer support for several other RAPS studies. Software developed for these studies included data validation, analysis and display routines.

The RAMS data processing included the reprocessing of data collected prior to January 1, 1976. Monthly and quarterly summaries of RAMS data were also generated in support of other studies.

The software packages developed under previous task orders, were implemented to process helicopter data (Section 5.0) and gas chromatography laboratory data (Section 7.2.1). An additional software package was developed and implemented to process the subsurface heat flux data (Section 6.2.1.2).

A modified version of the RAMS remote data acquisition software was developed for continued operation of several sites in a non-network environment. This software provided for independent operation of the RAMS sensors and calibration system, and enabled the instrument handler scheme to activate channels on an individual basis.

In lieu of a final report, documentation of the various software packages and the processed data were submitted to the EPA Task Coordinator. Additional information may be obtained from:

RAPS Data Manager (MD-80)
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Publication

None

16.0 MODEL EVALUATION AND DEVELOPMENT

Introduction

One of the major objectives of RAPS is the evaluation of existing mathematical air quality simulation models, using regional air quality, meteorological, and emissions data obtained during the field measurement program. Emphasis has been placed upon deterministic, physically-based relationships between emissions and ambient air quality in preference to predictive formulations. Development of new models, while important particularly in the areas of pollutant transformation and removal, is of secondary priority in the RAPS modeling effort.

The modeling effort is being conducted by and under contract to the Meteorology and Assessment Division of the Environmental Sciences Research Laboratory at Research Triangle Park. Although several models have been adapted to the St. Louis Region, testing of these models has necessarily had to await the results of the field measurement program. The following is a summary of models and model types that are being considered for evaluation.

16.1 POTENTIAL CANDIDATE MODELS

16.1.1 IBM'S SULFUR DIOXIDE MODELS IBMAQ-1 AND IBMAQ-2

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Project Officer

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Funding EPA Contract No. 68-02-1833

Period of Performance July 1974 - May 1975

Summary

IBMAQ-1 is a generalized urban air pollution model based on numerical integration of the concentration equation. It is designed to deal with the inhomogenity of multiple-source emissions, the complex urban atmosphere, and the change of surface boundary conditions. For this purpose, a method based on experiments and an earlier turbulence transport model is used to estimate the turbulent diffusivity and atmospheric stability. The concentration differential equation is solved by means of a finite-difference scheme with special treatments to accomodate large variations of concentrations encountered in the urban area.

IBMAQ-1 was used to model SO_2 concentration distributions in the St. Louis Metropolitan Area during twenty-five consecutive days in February 1965. The computed results were found to agree well with experimental measurements for both long-term and short-term average concentrations.

IBMAQ-2 is a more advanced urban air quality model and represents a further development and refinement of IBMAQ-1. It was originally designed to use point and area source data from NEDS (National Emissions Data System) and RAMS (Regional Air Monitoring System) data from the St. Louis area, although the model development preceded much of the St. Louis RAMS data acquisition. The urban surface roughness values, estimated from measured mean building heights and calculated building density, are treated explicitly as input parameters. The model also uses a new method to incorporate point sources into the grid computation by means of Lagrangian trajectories.

The computer code of IBMAQ-2 is constructed in a modular form which allows users to change or improve each component of the model conveniently. Many modeling options are provided, including choice of (a) surface wind field, (b) vertical variation of wind field, (c) vertical wind components, (d) concentration adjustment with mixing height variation, and (e) point source modeling.

Publications

Shir, C. C., and L. J. Shieh. A Generalized Urban Air Pollution Model and Its Application to the Study of SO_2 Distributions in the St. Louis Metropolitan Area. Journal of Applied Meteorology, 13 (2): 185-204, 1974.

Shir, C. C., and L. J. Shieh. Development of an Urban Air Quality Simulation Model with Compatible RAPS Data. Volumes 1 and 2. IBM Research Laboratory, San Jose, California. EPA Contract 68-02-1833. May 1975. EPA-600/4-75-005-a&b.

16.1.2 LAWRENCE LIVERMORE LABORATORY'S LIRAQ-1 AND LIRAQ-2

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Funding

NSF Interagency Agreement AG-412
ERDA Contract No. W-7405-Eng-48
EPA Interagency Agreement IAG-D5-0738
EPA Interagency Agreement IAG-D7-01202

Periods of Performance

NSF AG-412	January 1973 - October 1975
EPA IAG-D5-0738	July 1975 - September 1977
EPA IAG-D7-01202	October 1977 - December 1978

Summary

Model Development

To simulate numerically the air quality in a region of complex topography and meteorology, a version of the mass continuity equation has been applied that is integrated vertically through the well-mixed layer below the inversion base. This approach maintains the capability for comprehensively treating the horizontal and temporal pattern of air quality as the inversion base height varies in space and time. The model formulation is based on several assumptions about the vertical variations of pollutant concentrations and wind velocity.

1. The horizontal components of the wind velocity vary vertically as a fractional power of the altitude above terrain.
2. The vertical pollutant profiles are in equilibrium with and determined by the balance of vertical eddy diffusion with surface sources and sinks.
3. The variation with altitude of the horizontal eddy diffusion coefficient does not significantly offset horizontal fluxes of pollutants arising from horizontal eddy transport.

Three processes which can transport pollutants across the interface between the well-mixed layer and the inversion are treated in the model - the diurnal heating of the earth's surface inducing vertical convection which entrains air into the mixed layer; evening cooling causing a new inversion layer below the daytime inversion and trapping pollutants in an elevated layer; and horizontal transport that creates a flux through a horizontal gradient of the inversion base.

Two models, LIRAQ-1 for non-reactive pollutants and LIRAQ-2 for photochemically reactive species, have been developed to solve the vertically averaged continuity equation.

In LIRAQ-1, horizontal advective transport is the dominant process. It is treated first for each time step, using an explicit, finite difference, flux-corrected transport scheme applied separately in the two horizontal directions. Next, any transport through the inversion layer is calculated by combining the air flux given by the mass consistent wind field calculation with the appropriate pollutant concentration. The horizontal atmospheric eddy motions are simulated with an eddy diffusion parameterization in which the diffusion coefficient is based on the energy dissipation rate and the grid size. Pollutant sources are taken from the emissions inventory compiled for the model on an hourly basis with a spatial resolution of 1 km. The sink mechanism treated in LIRAQ-1 is surface deposition, represented by a deposition velocity selected for each pollutant (chemically non-reactive) acting on the surface pollutant concentration determined from the vertical profile.

LIRAQ-2 is designed for realistic simulations of photochemically reactive species on a regional basis. This requires a physically meaningful treatment of both the complex photochemical and transport processes. Because of limitations on computer program size, however, LIRAQ-2 must sacrifice some capabilities in representing transport and number of grid elements to treat photochemistry in sufficient detail. In the treatment of the chemistry, there are 19 chemical species whose concentrations are calculated for each time step at each point of an Eulerian grid. The reactions of these species are modeled in terms of 48 reaction equations. Four of these species are assumed to be in instantaneous equilibrium during each time step, and therefore their concentrations are based only on their photochemical reactions. The calculation of the other 15 species include both dynamic and photochemical effects.

Typically, as applied to the San Francisco Bay Area, LIRAQ-1 deals with 2 pollutants and a 34 x 42 element, 5 km grid, with an approximate running time of 15 min for a 24 h simulation. With the simplifying assumptions mentioned above for LIRAQ-2, to treat the 15 active species, the spatial domain in LIRAQ-2 is limited to 20 x 20 grid cells (5 km grid size was used for the Bay Area). The typical running time of LIRAQ-2 for a 24 h simulation is about 60 min on the CDC-7600 computer.

Model Evaluation

Topographic, meteorological, source emission and atmospheric pollutant concentration data have been assembled for use in verifying the LIRAQ-1 and LIRAQ-2 regional air quality models in the San Francisco Bay Area. Verification studies have been performed using the data collected primarily during the high-pollution period of July 26-27, 1973.

Comparison of LIRAQ-1 model results with observations (hourly CO concentrations) indicated generally good agreement in magnitude, temporal phasing, and spatial patterns when allowance was made for grid size, spatial domain, and unrepresentativeness of suburban observation stations in primarily rural areas.

For regionally important photochemical pollutants, the LIRAQ-2 model simulated rather well both the very clean August and the very smoggy July days.

A particularly good fit was achieved for ozone in July, with the phasing of NO and NO_2 also well represented, but the use of the 5 km grid size apparently led to difficulties in simulating peak concentrations of primary pollutants.

From the limited number of sensitivity studies it appears that the initial and horizontal boundary conditions as well as grid size and subgrid-scale effects, while very significant in predicting air quality on the local scale, are less important in dealing with regional concentrations of pollutants than are emissions, meteorological conditions and vertical boundary conditions.

Publications

MacCracken, M. C. User's Guide to the LIRAQ Model: An Air Pollution Model for the San Francisco Bay Area. Lawrence Livermore Laboratory Report. UCRL-51983. Lawrence Livermore Laboratory, Livermore, California. 1975.

MacCracken, M. C., and G. D. Sauter, Editors. Development of an Air Pollution Model for the San Francisco Bay Area, Volumes I and II. Lawrence Livermore Laboratory Report. UCRL-51920. Lawrence Livermore Laboratory, Livermore, California. ERDA Contract W-7405-Eng-48. 1975.

MacCracken, M. C., D. J. Wuebbles, J. J. Walton, W. H. Duewer and K. E. Grant. The Livermore Regional Air Quality Model: I. Concept and Development. Journal of Applied Meteorology, 17 (3): 254-272, 1978.

Duewer, W. H., M. C. MacCracken, and J. J. Walton. The Livermore Regional Air Quality Model: II. Verification and Sample Application in the San Francisco Bay Area. Journal of Applied Meteorology, 17 (3): 273-311, 1978.

16.1.3 LAGRANGIAN PHOTOCHEMICAL MODELS

The general class of Lagrangian or trajectory photochemical models is characterized by the fact that the air mass to be modeled follows a path determined by the wind trajectory. Pollutants enter the volume and are mixed throughout as the volume passes over the various emissions sources along the trajectory. A relatively sophisticated chemical reaction model is required in order to model the complex mechanism of smog photochemistry. An example of a Lagrangian photochemical model is that developed by Environmental Research and Technology, Incorporated.

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Funding EPA Contract No. 68-02-2765

Period of Performance October 1977 - January 1979

Summary

The ELSTAR model (Environmental Lagrangian Simulation of Transport and Atmospheric Reactivity) is a numerical dynamic model for photochemical smog simulation. It determines the trajectory, based on surface wind measurements, of an air parcel across an emission grid network. It uses a finite difference solution of the vertical diffusion equation for the parcel and thus calculates pollutant concentrations within the parcel as a function of height and time. The photochemical reaction portion of the diffusion equation involves 64 reactions and 39 chemical species. The vertical eddy diffusivities are determined by a program sub-module using surface wind data and vertical temperature profiles. The model contains an individualized treatment of point sources which considers inversion penetration by individual sources. The effects due to lateral diffusion of point sources are also included in the model.

Publication

A Lagrangian Photo Chemical Air Quality Simulation Model: Adaptation to the St. Louis RAPS Data Base; Volume I: Model Formulation; Volume II: User's Manual. Environmental Research and Technology, Inc., Santa Barbara, California. EPA Contract 68-02-2765. In preparation.

16.1.4 MODEL BY THE CENTER FOR THE ENVIRONMENT AND MAN

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Funding

EPA Contract No. CPA 70-62
EPA Contract No. 68-02-0223
EPA Contract No. 68-02-1767

Period of Performance

Contract No. 68-02-1767	February 1974 - March 1976

Summary

The model developed by the Center for the Environment and Man is unusual in that it generates its own meteorology from initial and boundary conditions and solar radiation. It uses a combination of Gaussian puff and grid models and when applied to an appropriate data base, the model generates time-dependent, three dimensional meteorological and SO_2 pollutant fields. The Gaussian part of the model consists of a puff formulation specially tailored for compatibility with, and to accept meteorological forecasts from, the grid model. The grid model is a physically consistent, numerical hydro-dynamical air pollution model based on the conservation equation for mass (of air, atmospheric moisture and pollutant), momentum and heat. The model generates SO_2 pollutant fields with one hour time resolution.

The basic inputs to the model consist of emissions (heat and pollutant), air quality and supplementary meteorological data bases. Appropriate land use information and topographic maps are also used to characterize the earth's surface.

Publications

Pandolfo, J. P., and C. A. Jacobs. Tests of an Urban Meteorological Pollutant Model Using CO Validation Data in the Los Angeles Metropolitan Area. Center for the Environmental and Man, Hartford, Connecticut. EPA Contract 68-02-0223. May 1973. EPA-R4-73-025a.

Pandolfo, J. P., C. A. Jacobs, R. J. Ball, M. A. Atwater, and J. A. Sekorski. Refinement and Validation of an Urban Meteorological-Pollutant Model. Center for the Environmental and Man, Hartford, Connecticut. EPA Contract 68-02-1767. 1976. EPA-600/4-76-037.

16.1.5 SYSTEM APPLICATIONS INCORPORATED'S MODEL

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Funding

EPA Contract No. CPA 70-148
EPA Contract No. 68-02-0339
EPA Contract No. 68-02-2429
NSF Grant No. GK-35476

Period of Performance Ongoing

Summary

The SAI model is a numerical model for studying the dynamic behavior of photochemical air pollutants in an urban airshed. The model uses a finite difference solution of the atmospheric diffusion equation on a three dimensional grid overlaying the modeled region to obtain the temporal variation of pollutant at each cell on the grid. The vertical and horizontal turbulent transport is assumed proportional to the concentration gradient and the turbulent diffusivities are determined by a simplified K-theory. Detailed meteorological information is required, describing spatial and temporal variations of wind components and inversion base height. Initial pollutant concentration fields and pollutant boundary conditions must be specified.

Pollutants emitted from ground-level sources are injected into the bottom layer of grid cells; emissions from stacks are distributed among the grid cells aloft. Numerical solution is performed by method of fractional steps with advection treated by SHASTA algorithm; vertical diffusion and chemistry by the Crank-Nicholson method. A 35-step chemical reaction mechanism based on the reactions and reactivities of carbon bond types is used.

Publications

Reynolds, S. D., P. M. Roth, and J. H. Seinfeld. Mathematical Model of Photochemical Air Pollution: I. Formulation of the Model. Atmospheric Environment, 7:1033, 1973.

Roth, P. M., P. J. W. Roberts, M. K. Liu, S. D. Reynolds, and J. H. Seinfeld. Mathematical Modeling of Photochemical Air Pollution: II. A Model and Inventory of Pollutant Emissions. Atmospheric Environment, 8:97, 1974.

Liu, M. K., D. C. Whitney, J. H. Seinfeld, and P. M. Roth. Continued Research in Mesoscale Air Pollution Simulation Modeling: Volume I. Assessment of Prior Model Evaluation Studies and Analysis of Model Validity and Sensitivity. Systems Applications, Inc., San Rafael, California. May 1976. EPA-600/4-76-016a.

Reynolds, S. D., J. Ames, T. A. Hecht, J. P. Meyer, and D. C. Whitney. Continued Research in Mesoscale Air Pollution Simulation Modeling: Volume II. Refinements in the Treatment of Chemistry, Meteorology, and Numerical Integration Procedures. Systems Applications, Inc., San Rafael, California. May 1976. EPA 600/4-76-016b.

Lamb, R. G. Continued Research in Mesoscale Air Pollution Simulation Modeling: Volume III. Modeling of Microscale Phenomena. Systems Applications, Inc., San Rafael, California. May 1976. EPA-600/4-76-016c.

Jerskey, T. N., and J. H. Seinfeld. Continued Research in Mesoscale Air Pollution Simulation Modeling: Volume IV. Examination of the Reasibility of Modeling Photochemical Aerosol Dynamics. Systems Applications, Inc., San Rafael, California. May 1976. EPA-600/4-76-016d.

Reynolds, S. D. The Systems Applications, Incorporated Urban Airshed Model: An Overview of Recent Developmental Work. Proceedings: Volume II. International Conference on Photochemical Oxidant Pollution and Its Control.

Environmental Protection Agency, Research Triangle Park, North Carolina. January 1977. EPA-600/3-77-0016.

16.1.6 GAUSSIAN MODEL FOR INERT SPECIES (RAM)

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Funding Environmental Protection Agency

Period of Performance Ongoing

Summary

The Real-Time Air-Quality Model (RAM) is an example of those models based upon the assumptions of steady-state Gaussian dispersion. RAM is a short-term (one hour to one day) model developed by the Environmental Protection Agency for estimating pollutant concentrations due to point and area sources.

RAM makes use of the Gaussian plume model for the calculation of concentrations due to point sources. A narrow plume simplification is used in the calculation of concentrations from area sources. This simplification makes use of the fact that the plume of a point source is normally quite narrow as compared to the scale of changes in the area source emission rates. This implies that area sources which are not directly upwind of the receptor need not be considered in detail so that emissions may be considered constant in the crosswind direction.

Pollutant decrease due to chemical reactions which are characterized by an exponential loss of pollutant can be approximated by RAM. RAM is intended for use over level or gently rolling terrain where the assumption of a flat plane is reasonable.

Various receptor location options are available in RAM. The first option allows the user to specify fixed receptor locations. In the second option, RAM chooses receptor locations downwind of significant sources where concentration maxima are likely to occur. In the third option, receptor locations are determined by RAM so as to provide good coverage of a specific area.

The application of RAM to the RAPS data base will be done in-house with subsequent comparison of calculated versus observed concentrations to be performed by SRI International.

Publications

Novak, J. H., and D. B. Turner. An Efficient Gaussian-Plume Multiple-Source Air Quality Algorithm. Journal of the Air Pollution Control Association, 26 (8): 570-575, 1976.

Turner, D. B., and J. H. Novak. User's Guide for RAM (DRAFT). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, May 1977.

16.1.7 PHOTOCHEMICAL BOX MODEL

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Funding Environmental Protection Agency

Period of Performance Ongoing

Summary

The "box-approach" to photochemical air quality simulation modeling is a relatively simple structure from which to study a highly complex subject. A photochemical box model (PBM) has been developed at the EPA encompassing a newly formulated chemical kinetic mechanism containing 38 reactions and 24 different species describing the HC-NO_x-O_3 photo-oxidation cycle. This approach represents an urban area as a single stationary cell with fixed horizontal dimensions, on the order of 20 to 40 km on a side, and a temporally varying vertical dimension proportional to the depth of the well mixed layer. Each pollutant species being simulated is accounted for in the model by an ordinary differential equation composed of advective, volume expansion, chemical, and emissions (if any) terms.

Initial model development and testing of the PBM has drawn upon the RAPS data base for St. Louis. One-minute averaged solar radiation data are used in the calculations as well as providing the observed values for use in model validation. The upper and lower bounds on the mixed layer depth during a given model simualtion, requisite model inputs, are deduced from RAPS radiosonde data.

Comparison of PBM predictions with spatially averaged RAPS urban air quality monitoring observations will be performed in-house for a select number of days reflecting a variety of meterological and emissions conditions.

Publication

Schere, K. L., and D. L. Demerjian. A Photochemical Box Model For Urban Air Quality Simulation. Proceedings of 4th Joint Conference on Sensing of Environmental Pollutants. American Chemical Society, 427-433, 1978.

16.1.8 GIFFORD-HANNA MODEL

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Period of Performance Ongoing

Summary

The Gifford-Hanna model is an urban area source model based upon the assumption of a Gaussian pollutant distribution in the vertical and using a narrow plume approximation in the horizontal direction. The narrow plume approximation is based upon the fact that the plume of a point source is normally quite narrow as compared to the scale of changes in the area source emissions patterns. This implies that area sources that are not directly upwind of a receptor need not be considered in detail so that emissions may be considered constant in the crosswind direction. The Gifford-Hanna model can then be formulated by a one-dimensional integral along the upwind azimuth from the receptor to the edge of the urban area source grid. Observations indicate that those sources outside the immediate area of the receptor grid square do not have a great influence on the receptor concentration. This observation leads to a further simplification of the model in which the receptor concentration is found to be proportional to the local area source strength divided by the wind speed.

Publications

Gifford, F. A., and S. F. Hanna. Urban Air Pollution Modeling. Paper No. ME-320, In: Proceedings of the Second International Clean Air Congress, Washington, D. C. December 1970. pp. 1146-1151.

Hanna. S. R. A Simple Method of Calculating Dispersion from Urban Area Sources. Journal of the Air Pollution Control Association, 21 (12): 774-777, 1971.

Gifford, F. A., and S. R. Hanna. Modeling Urban Air Pollution. Atmospheric Environment, 7: 570-575, 1973.

16.1.9 SYSTEMS APPLICATIONS' REACTIVE PLUME MODEL

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California Air Resources Board Contract No. ARB 4-258
EPA Contract No. 68-02-2775

Periods of Performance

September 1974 - April 1976
March - December 1978

Summary

The SAI reactive plume model (RPM) is based on a number of simplifying assumptions that approximately characterize the complex transport and diffusion processes thus allowing a rather detailed modeling of the plume chemistry. The plume geometry is characterized by two simple parameters, its effective width and the depth of the mixed layer which are both taken to be dependent upon the downwind distance. It is further assumed that the wind speed is uniform (but can be a function of time) and that the pollutant distribution is homogeneous at any cross section perpendicular to the plume axis.

A set of coupled, first-order, nonlinear ordinary differential equations, based on consideration of mass flux balance for each pollutant species, is solved in the model by using a slightly modified Gear routine.

Despite its conceptual simplicity, the SAI reactive plume model can be used for many practical purposes, such as:

(1) Prediction of the concentration variations of secondary pollutants, such as ozone.

(2) Estimation of the rate of production of sulfate and nitrate in the plume (Heterogeneous processes have not been considered in the model).

(3) Differentiation between decreases in pollutant concentrations due to chemical reactions and those due to plume dispersion.

Although the model was originally designed for prediction of industrial plume transport and interaction, it appears that it can also be used to model the more extensive urban plumes. The model validation was carried out only for power plant plumes. The plume data used for model validation were gathered downwind from the Moss Landing Power Plant near Monterey, CA and the Haynes and Los Alamitos Power Plants in the Los Angeles Basin. Based upon an overall appraisal of the results of the validation study, the model predictions compare quite well with the measured values for all measured pollutant species (NO, NO_2, O_3, and SF_6) except sulfate ($SO_4^=$).

The restrictive assumption of homogeneity within each air parcel in the original model formulation has recently been removed in an improved version of the reactive plume model (RPM-II). The revised model assumes an array of well-mixed cells across the plume with cell boundaries that are viewed as impermeable for primary pollutants. Also, a more up-to-date kinetic module, the Carbon-Bond Mechanism, has been incorporated. Results of comparisons between predictions of the revised model and field measurements from the RAPS and MISTT studies will be reported.

Publications

Liu, M. D., D. Durran, P. Mundkur, M. Yocke, and J. Ames. The Chemistry, Dispersion, and Transport of Air Pollutants Emitted from Fossil Fuel Power Plants in California: Data Analysis and Emission Impact Model. Systems Applications, Inc., San Rafael, California. ARB Contract ARB4-258. May 1976.

Liu, M. K., M. A. Yocke, and P. V. Mundkur. Numerical Simulation of Reactive Plumes. Air Series, American Institute of Chemical Engineers. 1976.

Liu, M. K. Development of a Mathematical Model for Simulating Power Plant Plumes. Presented at the Fourth International Clean Air Congress, Tokyo, Japan. May 1977.

Ogren, J. A., D. L. Blumenthal, W. H. White, T. W. Tesche, M. A. Yocke, and M. K. Liu. Determination of the Feasibility of Ozone formation in Power Plant Plumes. EPRI EA-307, Electric Power Research Institute, Palo Alto, California. 1976.

Liu, M. K., D. A Stewart, and P. M. Roth. An Improved Version of the Reactive Plume Model (RPM-II). Presented at the NATO/CCMS 9th International Technical Meeting on Air Pollution Modeling and its Application, Toronto, Canada. 1978.

APPENDIX A

LISTING OF RAPS TASK ORDERS

TASK ORDER	TITLE
Number 1	RAPS Program Planning
Number 2	Summer 1973 Boundary Layer Study Helicopter Support
Number 3	Gas Chromatography Laboratory Operation
Number 4	Summer 1973 Boundary Layer Study Pibal Support
Number 5	RAPS Office Relocation
Number 6	Summer 1973 Aerosol Characterization Study Aircraft Support
Number 7	Summer 1973 Aerosol Characterization Study Meteorological Support
Number 8	Cancelled
Number 9	RAPS Program Objectives and Plans
Number 10	Computer Graphics Planning and Support
Number 11	Investigation of the Significance of Aircraft Emissions on Stratospheric Aerosols
Number 12	Cancelled
Number 13	Computer Graphics Interface with RAPS Data Base
Number 14	St. Louis CAMP Station Operation
Number 15	Winter 1974 Boundary Layer Study Helicopter Support
Number 16	Point Source Criteria Pollutant Emission Methodology and Inventory
Number 17	Field Experiment Emission Inventory Methodology
Number 18	Winter 1974 Boundary Layer Study Pibal and Radiosonde Support
Number 19	Winter 1974 EPA Aerosol Lab Trailer Support
Number 20	RAPS Emission Inventory Data Handling System
Number 21	Gas Chromatography Laboratory Operation
Number 22	Computer Graphics Development for the RAPS Data Base
Number 23	Catalyst Sulfate Study Design and Installation
Number 24	Cancelled
Number 25	RAPS Helicopter Aerial Monitoring System Installation
Number 26	Effects of Airborne Sulfur Pollutants on Materials

(continued)

TASK ORDER	TITLE
Number 27	LBL Dichotomous Aerosol Sampling Network
Number 28	Visibility Model - Correlation of Light Scattering with Other Atmospheric Parameters
Number 29	RAMS Aerosol Inlet Modification for LBL Automatic Dichotomous Aerosol Samplers
Number 30	Cancelled
Number 31	RAPS Upper Air Sounding Network
Number 32	Winnebago Laboratory Van Instrumentation
Number 33	Summer 1974 Brookhaven Plume Study Pibal Support
Number 34	Cancelled
Number 35	Summer 1974 Nelson Streaker Study
Number 36	Catalyst Sulfate Study Sample Analyses
Number 37	Update of RAPS Emission Inventory Handbook
Number 38	Point and Area Source Heat Emission Inventory
Number 39	Emission Inventory Precision Analysis
Number 40	Computer Support for RAPS Field Activities
Number 41	Summer 1974 Aerosol Characterization Study Aircraft and Pibal Support
Number 42	Cancelled
Number 43	Summer 1974 Long Path-Pollutant Variability Study
Number 44	Winnebago Laboratory Van Operation
Number 45	RAPS Helicopter Data Translation and Verification
Number 46	Summer 1974 Meteorological Upper Air Support
Number 47	Summer 1974 Boundary Layer Study Pibal Support
Number 48	Summer 1974 Boundary Layer Study Helicopter Support
Number 49	Summer 1974 High Volume Filter Measurements
Number 50	RAPS Expedition Research Program
Number 51	High Volume Filter Measurements of Suspended Particulate Matter
Number 52	Investigation of the Significance of Aircraft Emissions on Stratospheric Aerosols
Number 53	Gas Chromatography Laboratory Operation
Number 54	Point Source Non-Criteria Pollutant Emission Inventory

(continued)

TASK ORDER	TITLE
Number 55	Point Source Criteria Pollutant Emission Inventory
Number 56	Sulfur Compounds and Particulate Size Distribution Inventory
Number 57	Modification of RAMS Dew Point Sensors
Number 58	RAPS Quality Assurance Audits
Number 59	Summer 1975 Brookhaven Plume Study Pibal Support
Number 60	Summer 1975 Boundary Layer Study
Number 61	Summer 1975 MISTT Plume Study Pibal Support
Number 62	Summer 1975 Nelson Streaker Study
Number 63	Summer 1975 SF_6 Plume Tracer Study
Number 101	High Volume Filter Measurements of Suspended Particulate Matter
Number 102	LBL Dichotomous Aerosol Sampling Network
Number 103	Gas Chromatography Laboratory Operation
Number 104	Subsurface Heat Flux Study
Number 105	Fall 1975 Brookhaven Plume Study Pibal Support
Number 106	RAPS Quality Assurance Audits
Number 107	RAMS/RAPS Field Data Processing
Number 108	RAPS Emission Inventories
Task 108A	Point Source Criteria Pollutant Emission Inventory
Task 108B	Criteria and Non-Criteria Pollutant Source Testing Program
Task 108C	RAPS Data Handling System Enhancement
Task 108D	Stationary Industrial Area Source Emission Inventory
Task 108E	Off-Highway Mobile Source Emission Inventory
Task 108F	Hydrocarbon Emission Inventory
Task 108G	Point and Area Source Heat Emission Inventory
Task 108H	Emission Inventory Handbook Update and Review
Task 108I	Point and Area Source Organic Emission Inventory
Task 108J	Emission Inventory Summary
Number 109	Winter 1976 Boundary Layer Study
Number 110	Acoustic Echo Sounder Operation
Number 111	EMI Plume Study Pibal Support
Number 112	Effects of Airborne Sulfur Pollutants on Materials
Number 113	Gas Chromatography Laboratory Operation

(continued)

TASK ORDER	TITLE
Number 114	DA VINCI II and III Pibal Support
Number 115	Summer 1976 MISTT Plume Study Pibal Support
Number 116	Summer 1976 Boundary Layer Study
Number 117	Streaker and Radiometer Operation
Number 118	Fall 1976 Boundary Layer Study
Number 119	Fall 1976 SF_6 Plume Tracer Study
Number 120	RAMS Transition Support
Number 121	CO_2 Effect on RAMS Sulfur Monitors
Number 122	RAPS Data Base Augmentation
Number 123	RAMS Station Relocation
Number 124	Fugitive Dust Survey and Inventory
Number 125	Evaluation of RAMS CO Data
Number 126	Cobb/Andrus Plume Study Pibal Support
Number 127	Aerosol Effects on Visual Range
Number 128	UASN Mixing Depth Determination
Number 129	RAPS Emissions Inventory Quality Assurance Program
Number 130	Cobb/Andrus/Breed Plume Study Pibal Support
Number 131	Documentation of Sources and Land Use Around RAPS Sites